Saskatchewan
Energy and Mines

Saskatchewan
Geological Survey

Report 203

Basement Geology, Part of the Cree Lake (South) Area

Part of NTS Area 74G

by C. F. Gilboy

1985

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Submitted May, 1980
Edit completed April, 1981
Text to printer (on disk) April, 1982
Printed April, 1985

Foreword

This report is published by the Saskatchewan Geological Survey as one of a series of reports resulting from a four-year program of geoscience surveys under the terms of the Canada-Saskatchewan Agreement on Mineral Exploration and Development in Northern Saskatchewan. This program is supported by funds provided by the Federal Departments of Energy, Mines and Resources (25 percent) and Regional Economic Expansion (25 percent) as well as by the Province of Saskatchewan (50 percent).

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September, 1981.

Abstract

The sub-Athabasca Group crystalline basement of the Cree Lake area is composed mainly of felsic gneisses, some of probable Archean age. Supracrustal rocks, commonly pelitic or semipelitic in composition, crop out sporadically throughout the region as lenses or as narrow bands, up to about 1 km wide and 60 km long. Some, and perhaps all, are of probable Aphebian age.

The rocks in the extreme east probably lie within the Wollaston Domain, those in the centre, in the Mudjatik Domain, and those in the west, in the Virgin River Domain. Whereas the junction between the Wollaston and Mudjatik Domains is gradational, the Mudjatik and Virgin River Domains are separated by a major tectonic lineament, the Cable Bay Shear Zone.

In the Wollaston Domain, compositionally and texturally homogeneous granitic gneisses are overlain by tourmaline-bearing metasediments of the Wollaston Group which show few signs of migmatization. No major folds have been recognized, but foliation trends vary from northeasterly in the southern part of the map area to northwesterly in the northern part.

In the Mudjatik Domain, the felsic gneisses show more compositional and textural variation. They have been folded, along with highly migmatized metasediments, into dome-and-basin structures. Hypersthene, indicative of granulite facies metamorphism, is widespread throughout most of the domain.

In the Virgin River Domain, felsic rocks are commonly homogeneous. They differ from their counterparts in the Wollaston Domain in that they tend to lose thermotectonically superimposed fabrics through recrystallization or remobilization. The metasediments show few signs of migmatization or the development of tourmaline. They also lack cordierite, which is so abundant in the Mudjatik and Wollaston Domains. Foliation and lithologic trends indicate a structural style similar to that of the Wollaston Domain. Widespread late-stage retrogression has affected both the felsic gneisses and the supracrustal rocks in the western part of the map area.

Four deformational events (D_1 to D_4), all of probable Hudsonian age, have been recognized. The first three phases are associated with a prolonged period of upper amphibolite to granulite facies metamorphism, which peaked at about 4.5 kb and 725°C, and destroyed most of the primary structures in the supracrustals. The first deformation (D_1) produced a regionally developed gneissic foliation and/or schistosity; no genetically related folds have been identified. During the second phase (D_2), best seen in the Mudjatik Domain, large west-northwest-trending upright folds developed. The production of later upright folds with northeast-trending subhorizontal axes resulted in the formation of domes and basins during the third phase (D_3). By this stage, metamorphic conditions in the Mudjatik Domain had waned to a pressure of about 3.7 kb and a temperature of about 650°C. The final event (D_4) was characterized by shearing which, although generally localized, attained considerable geological importance in the Cable Bay Shear Zone. It was accompanied by regional retrogression, particularly in the west.

Intrusive rocks, mostly granitoids, form recognizable plutons in the western part of the Mudjatik Domain. Most seem to have been emplaced before or during D_1. However, late, mostly massive granites were emplaced in both the Mudjatik and Virgin River Domains as plugs and plutons and, more commonly, as sharply cross cutting dykes. Uplift and erosion was followed by deposition of the Athabasca Group conglomerates and sandstones under mainly fluviatile conditions.

The injection of diabase dykes, mainly concentrated in a 6 km wide northwest-trending zone (the Cree Lake dyke swarm), at about 1100 to 1200 Ma was followed by regional fracturing and some faulting.

Although no economically viable mineralization is presently known, the geologic setting is suitable for the formation of Key Lake-type uranium deposits. Of marginal interest is the VH iron deposit, which is located close to the western edge of the area and contains an estimated 23 to 27 million tonnes of ore grading 32 percent Fe.

Keywords: NTS 74G, Precambrian, Archean basement, Aphebian metasediments, Wollaston Domain, Mudjatik Domain, Virgin River Domain, Cable Bay Shear Zone, Hudsonian orogeny, diabase dykes, petrography, geochemical analyses, geochronology, Nyberg Lakes iron deposit

Gilboy, C. F. (1985): Geology of the Precambrian basement south of the Athabasca Group, part of the Cree Lake (South) area; Saskatchewan Energy and Mines, Report, 203, 47p.

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Introduction

Location and Access

The area is bounded to the east and west by longitudes 106° 00′ W and 107° 45′ W, to the south by latitude 57° 00′ N and to the north by the southern edge of the Athabasca Group sediments. It encompasses an area of about 3650 km centred around American Lake and located 240 km north-northwest of La Ronge.

The area, easily reached from La Ronge by float-equipped aircraft, is also accessible via a landing strip at the Cree Lake weather station on the northern shore of Cable Bay. A winter road from Buffalo Narrows also serves the weather station. Travel within the area is easiest by light plane, as lakes and rivers suitable for canoe travel are rare.

Physiography

Much of the area is covered by flat, sparsely treed sand plain. It is most rugged in the west, as well as in the area adjacent to Leavitt Bay at the southwestern end of Cree Lake and in the region between the Gwillim River and Mudjatik Lake. The maximum topographic relief in each of these three areas is about 100 m. The summit of a large drumlinoid ridge immediately west of Dunsmore Lake is the highest point at 637 m above sea level, while the lowest is Cree Lake at 485 m.

The western part of the area is drained by the Brustad River into Leavitt Bay of Cree Lake and by the Gwillim River which flows southwards. To the east, the American, Routledge and Wheeler Rivers drain into Cree Lake. The major divide between the Mackenzie and Churchill River systems passes west-northwest through the western half of the map area. Lakes are numerous but generally small.

Bedrock outcrop is good except in the east, where hills are formed mostly by drumlinoid ridges. In areas covered by sand plain, outcrops are scattered but sufficient to provide adequate control for mapping purposes.

The topography is only partly influenced by the geology. In the central and western parts of the area, valleys and ridges tend to follow fractures and, to a much lesser extent, regional foliation trends. In the west, a steep northwest-facing scarp follows the northern part of the Cable Bay Shear Zone.

Glacial features include numerous drumlinoid ridges, particularly in the east and in those regions that are underlain by Athabasca Group sediments. These ridges are commonly terraced and eroded. The map area is also crossed by seven main northeast-trending esker systems with flanking glaciofluvial outwash plains composed of sand and gravel.

Remnants of older northwest-trending eskers are sporadically preserved (e.g. south of Lazy Edward Bay and west of Cable Bay). A recessional moraine, characterized by 'knob-and-kettle' topography, forms a belt up to 7.5 km wide which extends from the northwestern corner of the map area southeast and then east along the south shore of Cree Lake, as far as Blanchard Lake.

Eolian deposits are scattered throughout the area as U-shaped dunes, which generally close to the northwest, or as northwest-trending ridges.

Previous Regional Work

The earliest geological observations were made by Tyrrell and Dowling (1896), whose party ascended the Gwillim River to a point 4 km north of Solitude Lake and then portaged for about 3 km to a lake-tributary system leading into the Brustad River.

The first geological maps of the area were published by the Geological Survey of Canada (Sproule, 1941; Sproule and Downie, 1941) at a scale of 1:253 440 (one inch to four miles). This work formed the basis of all the more recent, larger scale geological maps including those of Rice (1951) at a scale of 1:506 880 and Whitaker and Pearson (1972) at 1:1 267 200.

Until the current boom in uranium exploration, the area received scant attention in terms of mineral exploration, except for work on the Nyberg Lakes iron deposit. All assessment work submitted to the Department of Mineral Resources has been indexed. Much of this material is non-confidential and is kept on open file for access to the public.

Coverage of the area is given by the following geophysical maps:

(a) 1:63 360 Federal-Provincial Aeromagnetic Series (published 1964): Maps 2752G to 2755G inclusive and 2768G to 2271G inclusive;
(b) 1:253 440 Federal-Provincial Regional Aeromagnetic Series (published 1966): Map 7157G;
(c) 1:250 000 Provincial Conductivity Anomaly Location Map Series (Standing, 1973): Map 74G;
(d) 1:1 000 000 Federal-Provincial Airborne Radioactivity Map of Northern Saskatchewan (published 1973): part of flight line 0; and
(e) 1:250 000 Federal-Provincial Airborne Gamma-ray Spectrometric Map (published 1976): flight lines 24 to 34 inclusive.

Petrologic Classification

All plutonic igneous rocks containing greater than 20 percent modal quartz are referred to as granitoid

rocks. The more detailed classification follows the system of Streckeisen (1976).

The term *felsic gneisses* is used in this report for quartzofeldspathic rocks whose primary origin is unknown. Where the mineralogy has been quantitatively determined, the rock name is preceded by an appropriate label (e.g. syenogranitic, monzogranitic), based upon the IUGS recommended nomenclature of igneous rocks. Berthelsen's (1960) classification is used for mafic gneisses that contain plagioclase, hornblende, orthopyroxene and/or clinopyroxene (see Figure 1).

An informal classification for metasedimentary rocks, using high alumina minerals, feldspar and quartz in a ternary diagram, is shown in Figure 2.

Where two or more mineral prefixes modify a particular rock type, the least abundant mineral is placed first and is followed by other minerals in order of increasing abundance (Streckeisen, 1976).

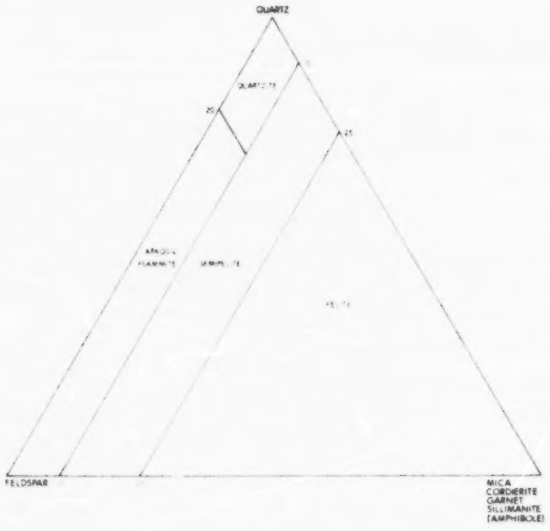

Figure 2. *Informal classification of metasediments*

Field Work

The area was mapped during the summer of 1977 using pace-and-compass traverses at 1 to 3 km intervals, normally perpendicular to the regional strike. Very little shoreline geology was carried out; only Barr Lake and Leavitt Bay were examined in this manner.

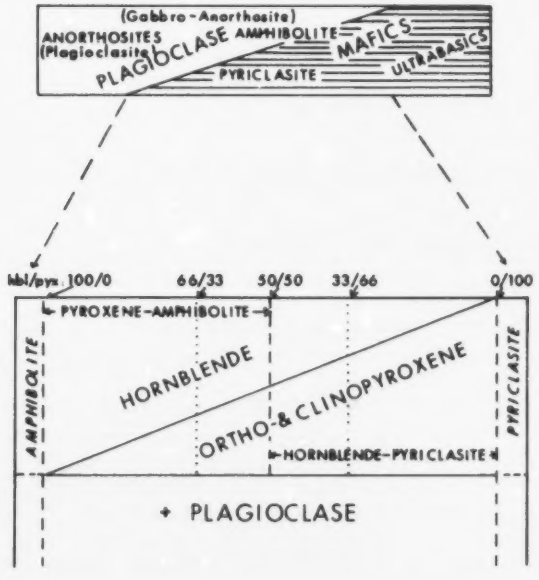

Figure 1. *Classification of mafic gneisses (after Berthelson, 1960)*

The present survey ran concurrently with a program of reconnaissance mapping of the southern edge of the Athabasca Group carried out by Ramaekers (1977). One result is a mutually derived accurate delineation of the contact between the Athabasca Group and the crystalline basement.

Much time, effort and money has been spent in the search for uranium at or near the southern margin of the Athabasca Basin. Most of the resulting data is currently confidential and unfortunately cannot be used in compiling the present report. Major revisions to parts of the accompanying map may be required when such information becomes public in the future.

Acknowledgements

The author was ably assisted by geologists Roberta Bald and Barry Jones, and by geological assistants Colm FitzGerald, Marnie Ferguson, Gary Smith and Gerry Toms. Terry Macfarlane and Mo Chubb piloted the Beaver aircraft and the Bell 47-G4 helicopter respectively (the latter being a one-week assignment) with much willingness, dedication and skill. The effective support of Department of Mineral Resources staff in both La Ronge and Regina is greatly appreciated. Finally, thanks are due to Shirley Shewchuk who provided the crew with many excellent meals.

General Geology and Petrography

The principal geological features of the area are shown in Figure 3.

Rocks cropping out along the eastern edge of the area have lithostructural characteristics that suggest they belong to the Wollaston Domain (Lewry and Sibbald, 1977, 1980). Granitic gneisses of probable Archean age are remarkably uniform in composition and texture. They appear to occupy a domal core and are overlain by Wollaston Group metasediments (Gilboy, 1975; Ray, 1975, 1977).

A change in rock types in the southeastern corner of the area marks the boundary between the Wollaston and Mudjatik Domains; in the Mudjatik Domain, the areally dominant felsic gneisses are lithologically variable and, in many places, waxy looking. Supracrustal rocks, which generally occupy long narrow bands (±500 m in width and up to 60 km in length), contain 30 percent or more of anatectic mobilizate. They may be of Aphebian age, but their stratigraphic relationship with the felsic gneisses is uncertain.

The Mudjatik Domain is separated from the lithologically distinct Virgin River Domain to the west by the Cable Bay Shear Zone, which strikes southwestwards from Cable Bay towards the Solomka Lakes in the southwest corner of the area. Rocks of the Virgin River Domain do not have the waxy appearance characteristic of those from the Mudjatik Domain. The supracrustals contain very little anatectic mobilizate, only occasional sillimanite and no cordierite.

To the north, the crystalline rocks of all three domains are covered by flat-lying conglomerates and sandstones of the Athabasca Group. The contact is so poorly exposed that its position is inferred mainly from scattered outcrop and boulder information (Figure 4).

The Athabasca Group sediments and to a lesser extent the older crystalline rocks were intruded by diabase dykes. These are concentrated in a 6 km wide zone which trends northwest through the area (Figure 3) and is referred to as the Cree Lake dyke swarm. The presence of diabase boulders in the vicinity of Seager Lake suggests that the swarm may extend into the southeast corner of the area (Figure 5).

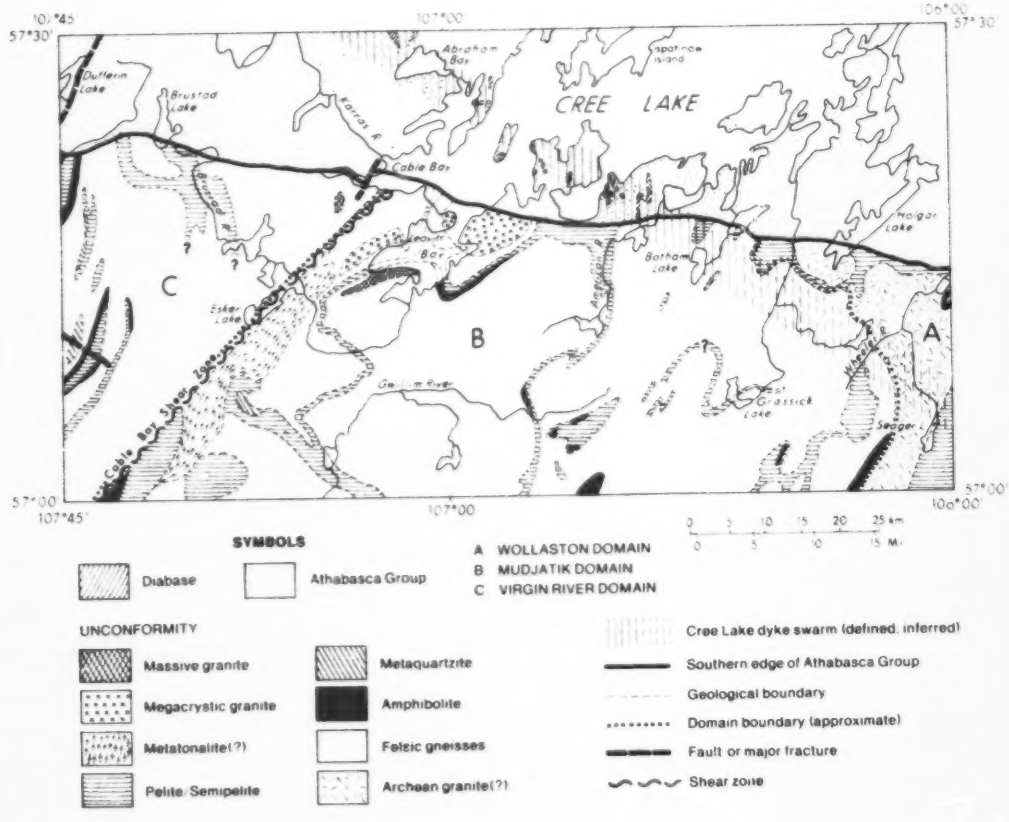

Figure 3. *Generalized geology of the map area*

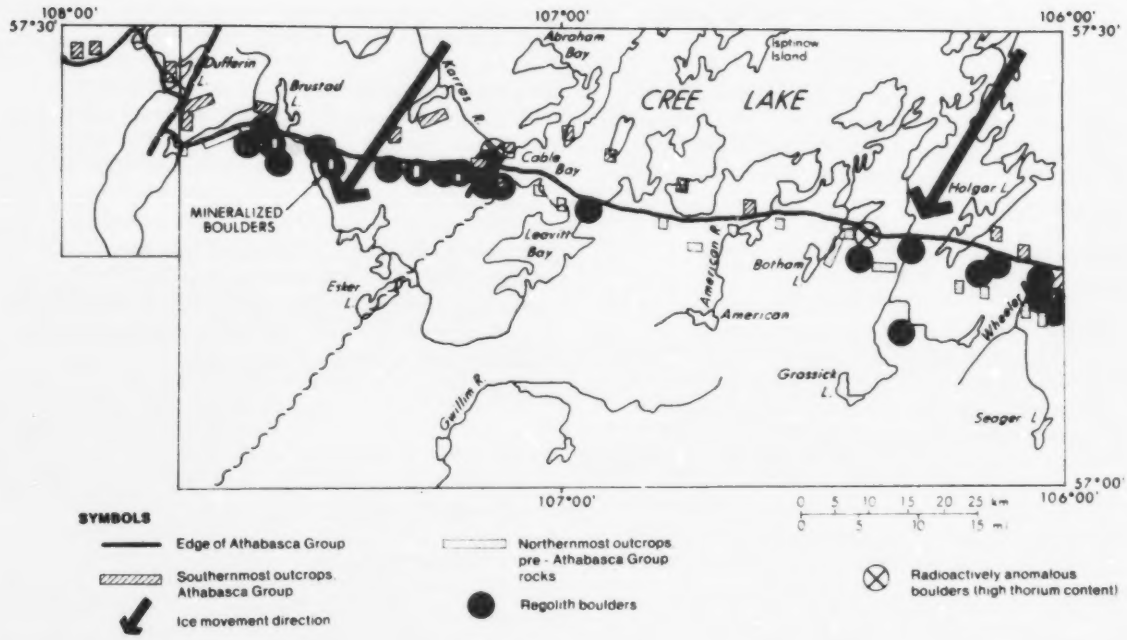

Figure 4. *Southern edge of the Athabasca Group*

Quaternary deposits include glacial till and esker-kame complexes. Drumlinoid ridges are common in an extensive area of thick till situated between Huston and Grassick Lakes and indicate an ice flow direction of 035° to 040°, similar to that suggested by glacial striae. Glaciofluvial sands, which commonly form outwash plains flanking the eskers, are best developed south of Leavitt Bay. Linear and hyperbolic dunes developed on these sands indicate a wind direction from the southeast (125° ± 10°). Wind fluting, in a direction similar to the dune elongation, is almost always found on the southeast-facing sides of rock outcrops in and close to major glaciofluvial sand deposits.

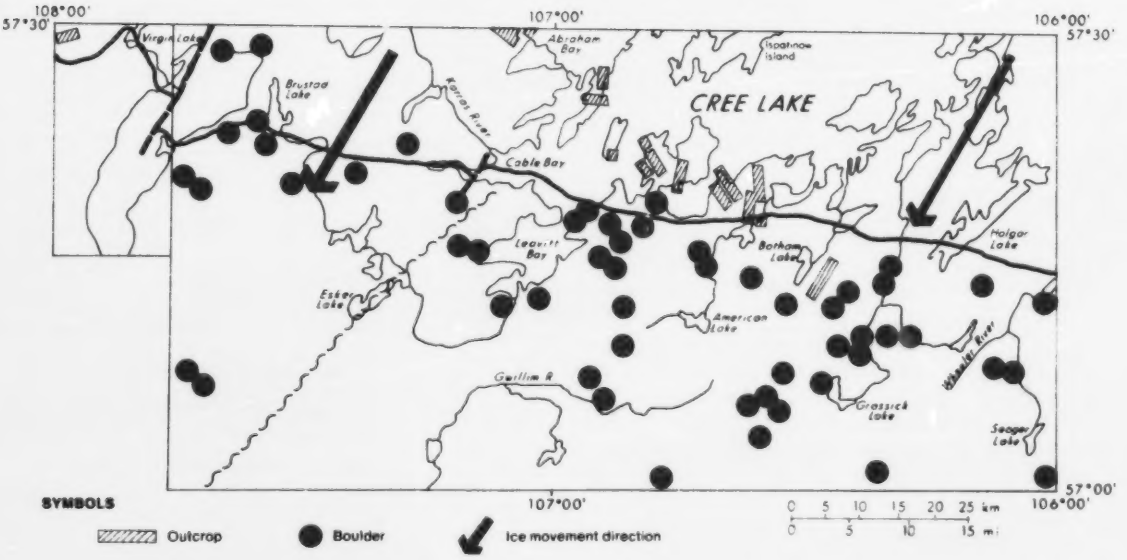

Figure 5. *Distribution pattern of diabase outcrops and boulders*

Wollaston Domain

General Geology

Exposure in the Wollaston Domain is generally poor, except in the south. The predominant rock type is a foliated, dark pink to red, medium- to coarse-grained gneissose *biotite and biotite-hornblende granite* (Units WGa, aa) containing about 5 percent mafics and a few evenly scattered microcline megacrysts 1 to 4 cm in length. Foliation is well developed and, in many places, distinctive; the mafic minerals are concentrated into thin (<1 mm) evenly spaced layers 3 to 6 mm apart. Homogenous pegmatitic material normally makes up less than 15 percent of exposures.

Metasediments, abundant in the southeastern corner of the area, show no observed contacts with the gneissose granites. Their outcrop area is too small to establish reliably their structural setting and, hence, to recognize any lithologic sequence such as those suggested for similar rocks elsewhere in the Wollaston Domain (Gilboy, 1975; Ray, 1975, 1977). They generally dip moderately to the southeast, away from the gneissose granites. Those outcrops that lie close to the granite are mainly medium- to fine-grained *pelitic and semipelitic biotite gneisses* (Units WPa, WSPa), locally containing graphite and/or garnet and/or hornblende. They are overlain by a zone of finer grained, more psammitic, pink or grey, slightly *calcareous quartzofeldspathic gneisses* (Unit WPSa) enclosing lenses of massive, scapolite-rich *calc-silicate* (Unit WC). In general appearance, the calc-silicates strongly resemble plutonic intrusive rocks. Farther to the southeast, medium-grained *pelitic and semipelitic biotite gneisses* (Units WPb, WSPb) overlie the calcareous unit. Rare cordierite, visually identified in conformable pegmatitic mobilizate, was not confirmed by thin-section examination. The extreme southeastern corner is occupied by fine- to medium-grained, psammitic to pelitic *quartzofeldspathic gneisses* (Unit WPSb) which are structurally the highest rocks in the domain.

To the north, in a zone between Wheeler Lake and a point midway between Holgar and Blanchard Lakes, a few metasedimentary boulders were found (Figure 6). They are generally less than 0.5 m in diameter and rarely exceed 1 m. Most are pelitic to semipelitic biotite gneisses with or without graphite, garnet and/or sillimanite. The absence of such boulders north of the assumed edge of the Athabasca Group sediments suggests that they are probably derived from a narrow strip of Wollaston Group metasediments lying beneath glacial deposits immediately south of the Athabasca Basin.

Biotite and Biotite-Hornblende Granite (Units WGa, aa)

Table 1a shows the visually estimated modal compositions from seven thin sections of gneissose granite from the Wollaston Domain. Specimen 0218 is atypical because of its high mafic content and lack of microcline. Collected from a small isolated exposure near the central reaches of the Wheeler River, it appears to lie more than 1 km east of the

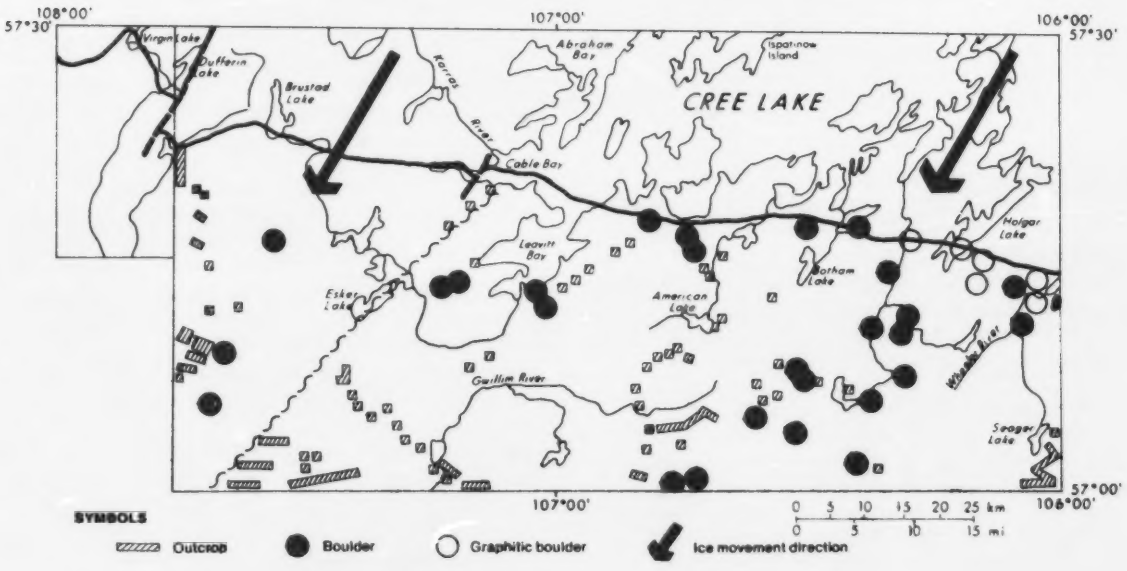

Figure 6. Distribution of metasediment outcrops and boulders

Table 1a. Visually estimated modal compositions of granitic rocks, possibly Archean basement of the Wollaston Domain (Units WGa, WGas)[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
0002	Syenogranitic hornblende-biotite gneiss	5 —	2 ∿**	33 ∿ Δ	20(An_{15})∝**	40 ∞*	Ap, Op(r), Sph(r), Zr
0003	Syenogranitic hornblende gneiss		5	20 ∇	25(An_{26})**	50 ∞	Ap, Op, Sph(r), Zr
0004	Syenogranitic biotite gneiss	5 ∿ ×		40 ∿ ∇	35(An_{15})	20 ∞	Ap(r), Op(r), Zr
0144	Syenogranitic biotite-hornblende gneiss	2 ×	5**	20 Δ	25(An_{25}) ∝*	48 ∞	Ap(ab), Chl, Op, Sph, Zr
0145	Monzogranitic biotite-hornblende gneiss	4 — ×	4*	22 Δ	30(An_{25}) ∝	40 ∞	Ap(ab), Op, Zr
0146	Syenogranitic biotite gneiss	4 — ×*		20 ∿ ∇	25(An_{24})	50	Ap(r), Op(1%), Zr
0218[2]	Tonalitic biotite-hornblende gneiss	6 — ×	24 ∿	20 ∇	50(An_{35})**		Ap(ab), Op, Zr(r)

[1]See Appendix A for explanation of symbols used.

[2]Petrographically atypical sample

assumed western limit of the Wollaston Domain. Its relationship to other rock types in the domain is not known.

Biotite flakes, present in five of the six typical thin sections, are up to 3 mm in length. Most are fresh and define a well-developed planar fabric, but some cut across the resulting foliation. They are dichroic from pale brown or (rarely) straw yellow to dark brown. Haloes are rare to moderately abundant. *Hornblende* generally occurs as randomly oriented xenoblastic crystals, which vary in length from 0.1 to 5.0 mm; most are shorter than 2.0 mm. They show a slight preferred orientation in only one section (0002[1]). Most grains are slightly to moderately altered to biotite, chlorite, sphene and opaque minerals, and poikiloblastically enclose quartz, plagioclase, microcline, zircon, apatite and opaque minerals. Pleochroic colours range from pale or moderate shades of brown to moderate or dark shades of green, rarely with a bluish tinge (0002).

Quartz invariably shows extreme undulose extinction; this often accompanies a weak preferred dimensional orientation of grains parallel to the biotite foliation. Crystals (0.1 to 4.0 mm in size) are much finer in the mafic-rich layers than in the felsic ones. Some large grains show incipient granulation (0144); others often enclose biotite, microcline, plagioclase, apatite and/or opaque minerals.

Plagioclase grains (An_{15-26}[2]) are locally slightly bent or fractured (0003, 0144, 0145, 0146), and enclose quartz, biotite, hornblende, apatite and/or zircon, as well as exsolved patches of potassium feldspar. *Microcline* microperthite occurs as irregularly shaped poikiloblasts, 0.1 to more than 8.0 mm in diameter, most of which display sharp cross-hatching. Exsolved plagioclase generally takes the form of intensely developed string or spindle-lamellae, blebs, patches or flame-like wedges. Quartz, biotite, hornblende, apatite or zircon grains are also enclosed.

Common *accessory minerals* include abundant xenoblastic apatite, as prisms up to 0.4 mm long; opaque minerals, as minute dusty inclusions in, for example, plagioclase and microcline, and/or as discrete xenoblastic to idioblastic equidimensional grains up to 2.0 mm in diameter; and zircon, which forms rounded to well-shaped grains up to 0.2 mm across. Xenoblastic sphene occurs sporadically with biotite, hornblende or opaque minerals.

The specimens are generally fresh, apart from slight to moderate sericitization of plagioclase and the alteration of hornblende to biotite, sphene, opaques, chlorite and/or a yellow-brown amorphous mineral.

Inequigranular interlobate granoblastic textures are most common; only in a single section (0003) is a polygonal granoblastic texture patchily developed in fine-grained areas. Traces of myrmekite are common at plagioclase/microcline boundaries.

Table 1b shows the visually estimated mode of a **regolith boulder**, probably derived from Wollaston

[1]Here, and throughout the rest of the report, the first four digits (77, indicating year of collection, and 08, indicating project identity) of an eight-digit departmental number are assumed, as they are common to all samples except for eight Mudjatik Domain felsic gneisses whose final four digits start with 3 (e.g. 3440, 3450). These latter samples were collected for radiometric dating in 1978; their first four digits are 7818.

[2]Plagioclase compositions were optically measured using the Michel-Levy method.

Table 1b. Visually estimated modal composition of 'regolith' boulder probably derived from Wollaston Domain granitoid rock[1]

Dept. No. (7708-)	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0143	'Regolith' derived from granitoid rock	3	30 ▽	?****	?****	Ap(r), Ms(r), Op(10%), Sph, Zr(ab)

[1]See Appendix A for explanation of symbols used

Domain gneissose granite. *Biotite* is dichroic in pale browns and greens. Flakes are wavy along their cleavage and reach 1.5 mm in length. *Quartz* is very highly strained, and many grains show incipient granulation. Many are fractured, with clay minerals infilling the cracks. *Feldspars* are completely altered to fine-grained sericite or kaolinite. Recognizable *accessory minerals* include rare apatite (up to 0.2 mm), very abundant zircon (up to 0.2 mm long), rare clear flakes of muscovite (up to 0.5 mm) and xenoblastic sphene. About 10 percent opaque minerals are scattered throughout the altered feldspars as minute grains less than 0.03 mm in diameter and as equidimensional poorly shaped discrete grains up to 0.8 mm across.

Wollaston Group Metasediments (Units WPa, b; WSPa, b; WPSa, b; WC)

Visually estimated modal analyses of 12 sectioned Wollaston Group metasediment samples are presented in Table 2.

Biotite is ubiquitous, making up 10 percent or more of all samples except 0210. The flakes, most of which are well aligned, range in length from 0.05 to 4.0 mm. Their dichroism is from pale brown or straw yellow to moderate brown, rarely to reddish brown (0205, 0210) or pale brown (0207, 0208). In several thin sections (0210, 0212), grains are richly spotted with haloes; only in 0215 are haloes notably rare. In specimen 0208, many flakes are bent in the hinges of folds which deform the primary gneissic foliation and schistosity; others are mimetically recrystallized around the hinges or are arranged parallel to the axial planes of the folds. In specimen 0209, biotite flakes are bent and/or kinked. *Amphibole* grains (generally less than 2 mm long) are normally randomly orientated, xenoblastic and pleochroic in very pale shades of straw yellow, brown, grass green and/or sea green. However, in specimen 0205, they show a weakly defined dimensional orientation and pale brown to moderate grass green and purplish green pleochroism. They enclose opaques and/or apatite, quartz, tourmaline, microcline and plagioclase, and are rarely intergrown with biotite. Some amphibole occurs as an alteration product of *clinopyroxene*, probably diopside. The neutrally coloured pyroxene is poorly shaped and most grains are less than 1.0 mm in size. *Scapolite* occurs as large poikiloblasts 0.1 to 4.0 mm in diameter

Table 2. Visually estimated modal compositions of Wollaston Group metasediments (Units WPSa, WSPa, WC, WPSb, WSPb, WPb)[1]

Dept. No. (7708-)	Rock Name	Map-unit	Biotite	Amphibole	Clino-pyroxene	Scapolite	Quartz	Plagioclase	Microcline	Accessory Minerals
0205	Pelitic biotite-amphibole gneiss	WSPa	10 — ×	20 ∿			20	50(An_{44})*		Ap(ab), Op, Zr(r)
0206	Calcareous semipelitic amphibole-biotite gneiss	WPSa	12 — ×	4	Tr	4	30	30(An_{46})**	37	Ap(ab), Op(r), To(2%), Zr
0207	Pelitic biotite gneiss	WPSb	30 — ×				20 Δ	38(An_{6})	5	Op(3%), To(4%), Zr
0208	Semipelitic biotite gneiss	WSPb	20 Λ ≈				20 — ▽ ≈	35(An_{48}) ∝ **	22 ∝	Ap, Ms, Op(3%), Sill(?), To, Zr
0209	Massive calc-silicate	WC	30 Λ ▽		55	12**		2(An_{25})		Ap, Op(r), Sph(1%)
0210	Semipelitic biotite gneiss	WSPa	1 ×	15			18 ∿ ▽	60(An_{7})*		Ap(ab), Cbt, Op(1%), Sph(ab), Zr
0211	Weakly foliated calc-silicate	WC	10 ∿	3	2***	60			20 ∝	Ap(1%), Op(2%), Sph(1%), Zr(r)
0212	Pelitic biotite gneiss	WPSa	25 — ×				30 ▽	20(An_{42})*	23 ∝	Ap(1%), Op(ab), To(1%), Zr
0213	Semipelitic biotite gneiss	WPb	20 — ×				35 ▽	20(An_{40})**	24 ∝	Ap(ab), Gr(?), Ms, Op (1%), Sill, Zr
0214	Semipelitic biotite gneiss	WPb	15 — ×				30 ▽	15(An_{37})**	40 ∝	Ap(ab), Gr(?), Ms, Op, To(r), Zr
0215	Slightly calcareous semi-pelitic amphibole-biotite gneiss	WPSa	12 — ×	4	4***	5*	20 ∿ ▽	30(An_{30})*	25	Ap(ab), Op, Sph, To, Zr
0216	Semipelitic biotite gneiss	WSPa	23 — ×				25 — ▽	20(An_{34})***	30 ∝	Ap(ab), Op(2%), To(r), Zr

[1]See Appendix A for explanation of symbols used

enclosing biotite (aligned in 0215) and/or tourmaline, opaques, plagioclase, quartz, apatite, microcline and zircon. It is slightly to moderately altered to chlorite.

Quartz, which occurs in all units except the calc-silicate rocks, varies in grain size from less than 0.1 to 4.0 mm, is commonly highly strained and shows weak or strong dimensional orientation in some sections. In specimen 0208, it also shows apparent elongation parallel to the axial planes of folds deforming the gneissosity. Quartz encloses apatite and/or plagioclase, zircon, biotite, microcline, tourmaline, zircon, sillimanite and opaques. *Plagioclase* (0.1 to 3.0 mm in size) is rare in the calc-silicates, but is elsewhere abundant and varies in composition from albite to andesine. It encloses biotite and/or quartz, amphibole, apatite, tourmaline, opaques, exsolved microcline (rare), zircon and sillimanite (rare). Normal zoning was distinguished in one sample (0215). *Microcline* is generally common and is faintly to clearly cross-hatched. It forms equidimensional grains ranging from less than 0.1 to 2.5 mm in diameter, and encloses quartz and/or biotite, tourmaline, zircon, opaques, apatite and sillimanite. Most thin sections contain at least a few grains with scattered flame-like exsolution lamellae of plagioclase developed near the crystal margins.

Accessory minerals include abundant apatite; xenoblastic to subidioblastic opaque minerals, which form up to 3 percent of the rock (0207); zircon as tiny xenoblastic (commonly rounded) crystals up to about 0.2 mm across; and tourmaline, which is remarkably widespread, locally abundant (up to 4 percent in 0207) as xenoblastic to idioblastic grains up to 0.4 mm in length, and dichroic from almost colourless, pale straw yellow or pale brownish green to pale yellow brown or moderate bluish green. Sphene, where it occurs, is abundant, especially in calc-silicate specimens where it forms large (up to 1.2 mm wide) pale brown xenoblasts. In other samples (0210, 0215), it forms much smaller crystals about 0.1 mm across and locally rims opaque grains. Muscovite occurs in several semipelites as finely crystalline terminations tc biotite and as 0.5 mm long flakes parallel and transverse to biotite cleavage planes. Ragged, elongated, opaque grains (possibly graphite) are also parallel to biotite cleavage planes. Sillimanite (0208, 0213) occurs in localized patches as acicular needles enclosed in other minerals such as quartz, microcline, plagioclase or, very rarely, biotite.

Widespread alteration is limited to the slight to moderate sericitization of plagioclase. Marginal replacement of diopside by amphibole (actinolitic ?), chloritization (0215) and possible uralization (0209) of scapolite, and the formation of carbonate from the breakdown of amphibole and/or plagioclase (0210) have taken place locally.

Equigranular interlobate granoblastic textures are common, but polygonal granoblastic textures are also widely developed. Slight suturing of interquartz boundaries is displayed in 0208. Traces of myrmekitic intergrowth are common.

Mudjatik Domain

General Geology

Bedrock exposure is good in a region whose corners are defined by Solitude Lake (in the southwest), Leavitt Bay (northwest), Botham Lake (northeast) and Beardall Lake (southeast), and in a second region west of Leavitt Bay. Because of poor exposure elsewhere, some reliance had to be placed on boulder occurrences, particularly in the northern part of the domain.

The majority of exposures are formed of pink *felsic gneisses* (Unit MF), some of which (Subunit MFa) are strikingly similar to possible Archean granitic basement (Units WGa, aa) in the Wollaston Domain. Outcrops of Subunit MFa are generally homogeneous and contain less than 15 percent pegmatitic mobilizate. The dark to moderately pink gneisses are well foliated and medium to coarse grained; they contain about 5 percent biotite and/or hornblende and scattered microcline megacrysts 1 to 3 cm in length. The felsic gneisses are not as lithologically homogeneous, on a regional scale, as similar rocks of the Wollaston Domain, so a total of four subunits have been recognized. Subunit MFb contains pale pink, poorly to moderately well foliated, medium- to coarse-grained gneisses containing about 5 percent biotite. The gneisses of Subunit MFc are pale pink, well foliated and medium to fine grained, and contain 5 to 10 percent biotite and, rarely, hornblende. Gneisses of Subunit MFd are generally greyish, medium grained, and compositionally and texturally banded; they contain 5 to 15 percent biotite and hornblende, and enclose amphibolitic blocks up to 5 m aross. In many places, felsic gneisses of two or more of these subunits crop out close to one another. However, these relationships were too complex for representation at the map scale used in this survey.

Felsic gneisses in this domain are commonly waxy looking. Two subdivisions were recognized for mapping purposes. The first (Unit MwFC) comprises waxy reddish brown *charnockitic felsic gneisses* which, in individual exposures, are often homogeneous, medium to coarse grained, well foliated and slightly megacrystic. They thus appear to be the waxy equivalents of gneisses belonging to Subunit MFa. Finer grained and equigranular varieties may be the equivalents of Subunit MFc gneisses. The second subdivision (Unit MwFE)

consists of waxy greenish brown *enderbitic felsic gneisses* which, where compositionally banded, appear to be the waxy equivalents of Subunit MFd gneisses.

A suite of felsic gneisses from Units MFa and MwFC (Figure 7a) was collected during the summer of 1978 for Rb/Sr dating at Carleton University (Tables 3, 4b, 7b). Bell (personal communication, 1979) states that, although the results show considerable scatter when plotted on an isochron diagram, they do indicate an Archean age (Figure 7b). The samples were also analyzed for major oxides and some trace elements at the geochemical laboratory, University of Regina (Tables 4a, b). The results do not help in the interpretation of the isotopic data.

Other foliated felsic rocks in the Mudjatik Domain exhibit notable compositional and textural homogeneity on a regional scale. In detail, however, they commonly contain variably sized blocks of different rock types which are often more mafic and perhaps represent original xenolithic material. These factors taken together indicate a probable plutonic igneous origin for the felsic hosts, despite their conformable (possibly transposed) contacts with the encompassing country rock. The largest and most abundant masses possessing these characteristics

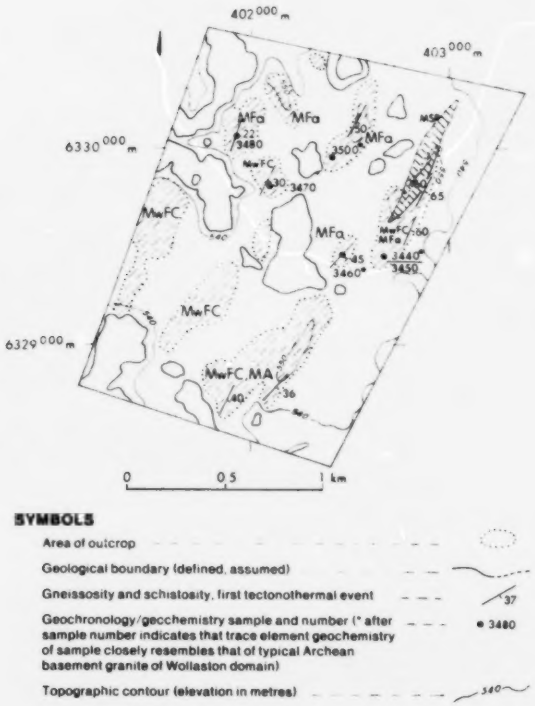

Figure 7a. *Locations of geochronological/geochemical samples (7818-); see Map 203A (Sheet 2) for location of this figure*

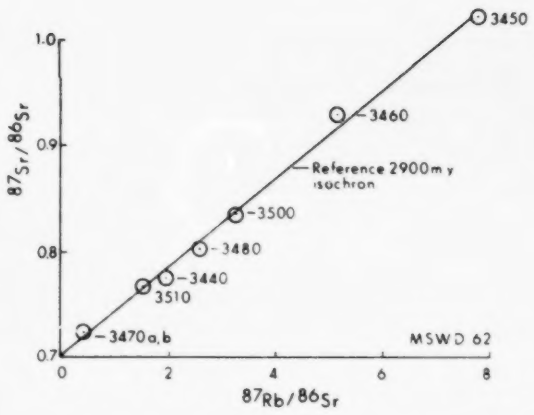

Figure 7b. *"Scatterchron" for Mudjatik Domain felsic gneisses of Units MFa and MwFC*

occur along the western edge of the domain (Figure 4) and include whitish *metatrondhjemites and metatonalites* (Unit MFT), pale pink *metagranodiorites* (Unit MFG) and pink megacrystic *metamonzogranite* (Unit MFM).

Mappable lenses of *amphibole gneiss* (Unit MA) are widespread and generally form narrow bodies up to 2 km long. They most often occur either along the contacts between the felsic gneisses and recognizable metasediments or within the metasediments close to such contacts. Hypersthene is ubiquitous in these mafic gneisses.

Semipelitic and pelitic gneisses (Units MSP, MP) are also widely distributed. They are generally coarse-grained, highly migmatized rocks rich in blue-grey cordierite, biotite, garnet and/or sillimanite. Graphite is locally abundant but does not seem to be confined to any particular stratigraphic levels. Most outcrops of these supracrustal rocks contain greater than 30 percent white or (rarely) pink pegmatitic mobilizate, occurring as concordant and cross-cutting veins in which vivid blue cordierite and

Table 3. Geochronological isotopic analyses[1] of Mudjatik Domain felsic gneisses (Units MFa, MwFC)

Sample No. (7818-)	*Rb (ppm)*	*Sr (ppm)*	*$^{87}Sr/^{86}Sr$ (atomic)[2]*	*$^{87}Rb/^{86}Sr$ (atomic)*
3440	128	190	0.7770	1.96
3450	240	94	1.0224	7.61
3460	215	122	0.9337	5.21
3470a	55	360	0.7247	0.44
3470b	74	518	0.7184	0.41
3480	138	154	0.8015	2.62
3500	169	153	0.8365	3.24
3510	112	211	0.7673	1.54

[1]Analyses carried out at Carleton University, Ottawa
[2]Normalized to a $^{86}Sr/^{88}Sr$ ratio of 0.1194

Table 4a. Major oxide analyses[1] of radiometrically dated Mudjatik Domain felsic gneisses (Units MFa, MwFC)

Dept. No (7818-)	SiO_2	TiO_2	Al_2O_3	Fe_2O_3[2]	MnO	MgO	CaO	Na_2O	K_2O	H_2O	LOI	Total
3440	72.8	0.50	12.5	3.11	0.04	0.42	1.45	2.97	4.40	0.13	0.28	98.63
3450	74.8	0.10	12.4	1.57	0.03	0.21	0.69	3.09	5.19	0.13	0.30	98.51
3460	75.1	0.39	12.3	2.90	0.05	0.33	0.92	2.89	4.60	0.08	0.29	99.85
3470a	70.4	0.33	14.9	2.64	0.03	0.90	2.42	4.16	2.50	0.16	0.49	98.93
3470b	68.6	0.42	14.7	3.73	0.05	1.38	2.39	3.71	3.12	0.02	0.46	98.58
3480	75.9	0.09	13.2	0.56	0.01	0.16	0.51	3.38	5.06	0.04	0.31	99.22
3500	71.6	0.56	12.4	3.81	0.05	0.54	1.29	2.73	4.98	0.21	0.38	98.55

[1]Analyses carried out at University of Regina
[2]Total Fe expressed as Fe_2O_3

wine red garnet are visually outstanding. *Psammitic gneissses* (Unit MPS) are sparsely represented.

Exposures of metasedimentary rocks are rare east of longitude 106° 40′ W (Figure 6). The outcrop pattern shown on the geological map for this region (Figure 3) is thus of doubtful accuracy. In the vicinity of Grassick Lake, structural trends and the distribution of metasediment boulders and outcrops suggest a folded, faulted band of pelites having a maximum thickness of 1 km and a strike length of approximately 20 km. There are also three much smaller lenses, one slightly to the southwest of Dunsmore Lake, the second 5 km northeast of Mudjatik Lake and the third 6 to 7 km northeast of American Lake.

West of longitude 106° 40′ W, metasediments are much more abundant than in the east though still volumetrically subordinate to the felsic gneisses. One band, with a width of about 1.6 km, has been traced for about 60 km. Metasedimentary bands whose maximum outcrop width exceeds 4.5 km occur in the southwestern corner of the domain. Unfortunately, sparse exposure in the key areas of this region prohibits reliable interpretation of the outcrop pattern. In the southwest, pure coarse-grained *quartzite*, intercalated with pelites and semipelites, is locally sufficient in abundance to permit mapping as a separate unit (Unit MQ).

Table 4b. Trace element analyses[1] of radiometrically dated Mudjatik Domain felsic gneisses (Units MFa, MwFC)

Dept. No. (7818-)	U	Nb	Zr	Y	Sr	Rb
3440	<0.2	18	285[2]	42[2]	115	130
3450	3.4	12	121	11	105	243
3460	0.9	20	253[2]	59[2]	121	210
3470a	<0.2	11	135	4.4	361	54
3470b	<0.2	12	123	13	549	78
3480	0.3	8.7	42	3.7	141	124
3500	0.7	16	355[2]	34[2]	154	168

[1]Analyses carried out at University of Regina
[2]Relatively high values for Zr and Y; these appear to be typical of 'Archean' basement gneissose granite in the Anderson Lake inlier of the Wollaston Domain (Gilboy, 1982)

Quartzite layers are thin and rare in the metasediments of the Mudjatik Domain east of longitude 107° 00′ W. The quartzites of the southwest may have undergone an easterly facies change, passing into more calcarous rock types. Although no marble or calc-silicate outcrops were seen, some calcareous boulders (up to 1.5 m in diameter) were found. These were probably not far from source.

Waxy *banded iron formation* (Unit MI) crops out in a 20 m wide band 6 km south of American Lake. The lens, enclosed by waxy felsic gneisses of Unit MwFC, probably represents a narrow, conformable layer of metasedimentary material.

Although the actual contact between the metasediments and felsic gneisses was not observed during the survey, in several places it was located to within 2 to 5 m. One such example can be seen on the north shore of a small unnamed lake 6 km southeast of Solitude Lake, where homogeneous, well-foliated, medium-grained, moderate pink felsic gneisses typical of Unit MFa are apparently conformably overlain by medium- to fine-grained, pale pinkish, semipelitic to pelitic garnet-biotite gneisses containing 0.05 to 2 m thick sillimanite- and/or cordierite- and/or graphite-bearing intercalations. Any angular discordances or basal conglomerates that may have existed have presumably been destroyed by subsequent intense metamorphism and deformation.

No recognizable sequence of rock types within the metasediments was established.

Biotite *leucogranite* (Unit MG) appears to be the youngest mappable rock type in the domain. Forming a large mass on the southern shore of Leavitt Bay, it is abundantly represented elsewhere by cross-cutting minor intrusions, most of which are too small to be shown at the 1:100 000 map scale.

Felsic Gneisses (Subunits MFa, b, c, d)

Tables 5a and b give the visually estimated modal analyses of 38 felsic gneisses from **Subunit MFa**, the

Table 5a. Visually estimated modal compositions of Mudjatik Domain felsic gneisses (Subunit MFa)[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
0001	Monzogranitic biotite gneiss	5 ×	Tr**	35 ▽	25(An_{23})∝**	35 ∞	Ap, Op, Zr
0005	Syenogranitic hornblende-biotite gneiss	4 —	1	35 ∿	10(An_{18})	50 ∞	Ap, Op, Zr
0006	Monzogranitic hornblende-biotite gneiss	4 —	1*	35	25(An_{20})∝*	35 ∞	Ap, Sph, Zr
0007	Monzogranitic biotite-hornblende gneiss	1 ×	3**	25	25(An_{16})∝*	45 ∞	Ap, Cp(1%), Zr
0008	Syenogranitic biotite gneiss	5 ∿ ×		30	20(An_{15})*	45 ∞	Ap(r), Op, Zr(ab)
0009	Syenogranitic biotite gneiss	4 ∿ ×		35 ∿	20(An_{19})∝*	40 ∞	Ap(ab), Op(1%), Zr
0010	Monzogranitic hornblende gneiss	Tr	5*	34	25(An_{21})∝*	35 ∞	Ap(ab), Op(1%), Zr (ab)
0011	Monzogranitic biotite-hornblende gneiss	1 ×	4	20 ∿	34(An_{24})	40 ∞	Ap, Op(1%), Zr
0012	Syenogranitic biotite-hornblende gneiss	4 ∿ ×	1**	20	15(An_{21})*	60 ∞	Ap(ab), Op(ab), Zr
0015	Monzogranitic biotite gneiss	5 ∿ ×		30	25(An_{26})*	40 ∞	Ap, Op, Zr
0016	Syenogranitic biotite-hornblende gneiss	3 ∿	4	25	28(An_{22})∝	40 ∞	Ap, Op(ab), Zr
0018	Monzogranitic biotite-hornblende gneiss	1 ∿ ×	3	35 ∿ Δ	25(An_{25})∝	40 ∞	Ap(ab), Op(1%), Zr
0019	Leucomonzogranitic hornblende-biotite gneiss	2 ×	1	30	30(An_{25})∝	37 ∞	Ap, Op, Zr(r)
0020	Monzogranitic biotite-hornblende gneiss	1 ×	4	35 —	30(An_{24})∝*	30 ∞	Ap(ab), Op, Zr(ab)
0021	Monzogranitic biotite-hornblende gneiss	4 — ×*	6*	15 ∿	40(An_{30})*	35 ∝	Ap(ab), Chl, Op(ab), Zr(r)
0022	Syenogranitic biotite-hornblende gneiss	2 —	3	35 —	15(An_{22})*	45 ∞	Ap, Op, Zr
0023	Syenogranitic hornblende gneiss	Tr	3	25 ∿	20(An_{24})	50 ∞	Ap(r), Op(1%), Zr (ab)
0024	Syenogranitic biotite-hornblende gneiss	1 ×	5	30 ∿	20(An_{21})*	43 ∞	Ap(ab), Op(1%), Zr(ab)
0025	Syenogranitic biotite gneiss	5 — ×		30 —	20(An_{22})∝*	45 ∞	Ap, Op(r), Zr
0026	Monzogranitic hornblende-biotite gneiss	3 — ×	1**	35 ∿	26(An_{23})∝	35 ∞	Ap, Op, Zr
0030	Granodioritic biotite gneiss	7 — ×*		20 ∿	55(An_{23})∝*	18 ∝	Ap(ab), Chl, Mu, Op (r), Zr(r)
0032	Granodioritic biotite gneiss	7 — ×**		20 ∿	53(An_{27})∝*	20	Ap(ab), Chl, Op, Zr(r)
0068	Monzogranitic biotite gneiss	5 ×		45	20(An_{26})∝	30 ∞	Ap(r), Op(r), Zr(r)
0075	Leucogranodioritic biotite gneiss	1 — ×		45 — Δ	35(An_{23})∝*	18 ∝	Ap(r), Op(1%), Zr(r)
0080	Monzogranitic biotite gneiss	4 ∿ ×	Tr*	25	40(An_{25})∝*	30 ∝	Ap, Op, Zr
0081	Granodioritic biotite gneiss	4 — ×		35 ▽	41(An_{21})∝	20 ∝	Ap, Op, Zr
0088	Syenogranitic biotite gneiss	5 ∿ ×		33 ∿ Δ	20(An_{21})	42 ∞	Ap(r), Chl, Op(r), Zr
0091	Leucosyenogranitic biotite gneiss	2 ×		25 Δ	25(An_{21})∝*	48 ∞	Ap(r), Op, Zr(r)
0112	Monzogranitic biotite gneiss	7 — ×**		28 ▽	30(An_{21})**	35 ∝	Ap, Chl, Op, Zr
0117	Leucomonzogranitic biotite gneiss	3 ∿***		32 ∿ ▽	30(An_{36})∝**	35 ∝	Ap, Chl, Ep, Op, Zr
0153	Monzogranitic hornblende-biotite gneiss	4 — ×	2	24 ∿ ▽	35(An_{26})∝*	35 ∞	Ap(ab), Op, Zr
0154	Monzogranitic biotite-hornblende gneiss	3 ∿ ×	4	20 ∿ ▽	35(An_{23})*	38 ∞	Ap(ab), Op, Zr(ab)
0229	Monzogranitic biotite gneiss	5 — ×		30 ▽	25(An_{21})∝**	40 ∞	Ap, Op, Zr

[1]See Appendix A for explanation of symbols used

Table 5b. Visually estimated modal compositions of Mudjatik Domain felsic gneisses (Subunit MFa) collected for radiometric dating[1]

Dept. No. (7818-)	Rock Name	Biotite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
3440	Syenogranitic biotite-hornblende gneiss	1 ×	5	35	18(An_{23})	40 ∞	Ap, Op(1%), Zr
3460	Syenogranitic biotite-hornblende gneiss	2 — ×	2**	30	20(An_{20})	45 ∞	Ap, Cbt, Op(1%), Zr
3480	Leucosyenogranitic biotite gneiss	2 ×		40	18(An_{24})	40 ∞	Ap(r), Op, Zr(r)
3490	Granodioritic hornblende-biotite gneiss	3 — ×	2	40	37(An_{27})	18 ∞	Ap, Bt, Op(ab), Zr
3500	Monzogranitic biotite-hornblende gneiss	2	3*	35	25(An_{24})∞*	40 ∞	Ap(ab), Op(ab), Zr

[1]See Appendix A for explanation of symbols used

rock type most closely resembling the gneissose granites (Archean?) of the Wollaston Domain.

Biotite is ubiquitous, although in several thin sections it only occurs in trace amounts. It is mostly dichroic from pale or moderate to moderate or dark shades of brown. Rarely, flakes possess a reddish tinge (0015, 0020, 3490) or, where they are an alteration product of amphibole (0007, 0026) or hypersthene (0015), they are dichroic in varying shades of yellowish brown. In altered areas of other samples (0030, 0032), biotite has pale straw yellow to green dichroic colours. Haloes are rare, and are developed around enclosed grains of zircon and apatite. Biotite is well to randomly oriented. However, even in slides where almost all the flakes show parallel alignment, rare cross-cutting flakes are also present. It occurs as evenly scattered flakes (0.1 to 1.5 mm long) or as concentrations in well-defined laminae (0005, 3460) which in places show shearing effects such as sutured grain boundaries and comminution of quartz grains (0006). Randomly oriented xenoblasts of *hornblende*, full of inclusions of apatite and/or biotite, opaques, plagioclase, quartz and zircon, are also present. Hornblende grains vary in size from less than 0.1 up to 2.0 mm, but occasionally reach 5.0 mm (0006). The smallest grains lack inclusions and are often idioblastic. Pleochroic colours include pale to moderate shades of brown, moderate or dark shades of grass green and, rarely, blue-green (0001, 0006). Hornblende is usually scattered evenly throughout the rock, but locally is confined to distinct layers (0010, 0023).

Quartz ranges in size from 0.1 to 4.0 mm, but in some sections (0075, 0091, 0117, 0154), a few crystals exceed 7.0 mm in diameter. Preferred dimensional orientation is commonly seen in many slides. Numerous grains in every section exhibit undulose extinction; locally this strain effect is intense, rarely to an extent where incipient breakdown in grain size occurs (0001, 0081). Quartz encloses all the other primary minerals: apatite, biotite, hornblende, microcline, plagioclase, opaques and zircon.

Plagioclase is mainly oligoclase, although andesine is sometimes found (0021, 0117). In general, grains range from 0.1 to 2.0 mm in diameter, but megacrysts in the range 4.0 to 10.0 mm are present in some thin sections (0009, 0025). The larger grains commonly exhibit slightly bent twin lamellae, minor fracturing with accompanying offset of lamellae (0018, 0032, 3440, 3490) and undulose exttinction. Compositional zoning (0001) is unusual, but partial or complete rimming of many crystals by clear albite up to 1 mm in width is a general feature, best seen in 0229 and 3460. Plagioclase encloses apatite, biotite, hornblende, quartz and opaques, and the larger crystals often have exsolved patches of microcline (antiperthite). *Microcline* commonly forms irregularly shaped grains which are generally in the size range 0.05 to 5.0 mm. Cross-hatched twinning is clearly (0009, 0011) to vaguely (0001, 0010, 0032) discernible in at least a few crystals in all thin sections. Cloudiness caused by enclosed minute opaque particles is commonplace (0001, 0023, 0229, 3460). Microperthitic exsolution of plagioclase is characteristic as string-like or spindly lamellae, small beads or blebs, flame-like marginal wedges or irregularly shaped patches. Several of these microperthitic forms are generally co-existent, especially in grains larger than 2.0 mm; there seem to be relative age differences, with early finely exsolved material followed first by coarser beads or blebs and then by yet coarser patches. Microcline encloses apatite and/or biotite, hornblende, opaques, plagioclase, quartz and zircon.

Common *accessory minerals* include xenoblastic to idioblastic apatite, subdioblastic to rounded zircon, and opaques. Apatite and zircon tend to be concentrated in relatively mafic-rich layers as crystals up to 0.3 mm across (exceptionally up to 0.5 mm). At least several zircon grains in many slides display one or more overgrowth shells. Opaque grains up to 2.0 mm across are typically equidimensional xenoblasts which, in places,

enclose apatite and/or quartz and zircon; they commonly constitute about 1 percent of the rock. Diopside has been identified in one section (3490).

Alteration products include some of the biotite (from hornblende and possibly hypersthene), chlorite (from biotite), carbonate (3460, from hornblende), epidote (0117, from hornblende), muscovite (0030, associated with biotite chloritization), sericite (affecting plagioclase in about two-thirds of the examined slides, in general only slightly) and sphene (0006, after hornblende).

Inequigranular and, less commonly, equigranular interlobate granoblastic textures are dominant. However, polygonal granoblastic textures occur in a few specimens, either locally, especially in fine-grained areas (0005, 0009, 0011, 0015 and others) or pervasively (0021, 3440, 3460). Trace amounts of myrmekite are ubiquitous, having formed along some plagioclase/microcline contacts.

Tables 6, 7 and 8 present modal compositions for the remaining three subunits of the felsic gneisses (MFb, MFc and MFd respectively). The petrography of these subunits broadly resembles that of Subunit MFa.

In **Subunit MFb** (Table 6), *biotite* is usually more randomly oriented and chloritized than it is in Subunit MFa. *Hornblende* is absent. *Quartz* shows a slight coarsening of grain size, with all sections (apart from 0060, 0061) containing a few crystals whose diameter exceeds 4.0 mm. *Plagioclase* (oligoclase) compositions consistently lie between An_{21-28}. *Microcline* is similar to that found in rocks of Subunit MFa. *Accessory minerals* include apatite (maximum grain size of 0.3 to 0.7 mm), zircon (which apparently lacks concentric overgrowths) and opaques. Muscovite (0097) forms late-generation interstitial grains about 0.5 mm long. The alteration of biotite to chlorite and of plagioclase to sericite is more widespread than in rocks of Subunit MFa. Inequigranular interlobate textures are dominant in all thin sections, but two (0045, 0061) show localized polygonal granoblastic textures. Traces of myrmekite are commonly present at plagioclase-microcline contacts.

In **Subunit MFc** (Table 7), *biotite* tends to be finer grained (0.1 to 1.0 mm) and more chloritized than in Subunit MFa. *Hornblende*, where present, is not abundant. Grains are mostly 0.1 to 1.0 mm in length, locally attaining 2.0 mm (0057). The smallest crystals are commonly idioblastic, but randomly oriented xenoblasts predominate and locally enclose apatite, microcline and quartz. Pleochroic colours are in pale shades of brown, grass green and bluish green, and moderate brown. *Quartz* shows preferred dimensional orientation in most of the 14 specimens. *Plagioclase* (mainly oligoclase) is slightly to extensively sericitized. Antiperthite is well developed in 0077 where, in addition to exsolved patches of microcline, blebs and string- and spindle-lamellae are present. *Microcline*, although generally finer grained (0.1 to 2.5 mm) than in Subunit MFa, is otherwise similar. *Accessory minerals* are also similar, except zircon which is mostly less than 0.2 mm across with extremely rare overgrowths. Opaque grains occasionally display a partial rim of biotite (0057, 0077) or sphene (0066, 0074). Muscovite is widespread (0055, 0066, 0073). *Alteration products* include chlorite, sericite and, in places, carbonate, epidote and sphene.

Inequigranular (and less commonly equigranular) interlobate granoblastic textures are well developed.

Table 6. Visually estimated modal compositions of Muskjatik Domain felsic gneisses (Subunit MFb)[1]

Dept. No. (7708-)	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0045	Leuco-alkali-feldspar granitic gneiss	1 ×	30 ▽	5(An_{21})	64 ∞	Ap, Op(ab), Zr
0060	Granodioritic biotite gneiss	5 — ×**	35 ∿	43(An_{28})α**	17 α	Ap, Chl, Op, Zr
0061	Granodioritic biotite gneiss	5 ×	25	59(An_{26}) α	10	Ap, Op(1%), Zr(ab)
0078	Monzogranitic biotite gneiss	3 — ×**	26 ∿	35(An_{26})α*	35 ∞	Ap, Chl, Op(1%), Zr
0097	Quartz monzonitic biotite gneiss	5 ×**	15 ▽	40(An_{23})α*	40 α	Ap, Chl, Ms, Op, Zr(ab)
0182	Monzogranitic biotite gneiss	5 — ×*	25 ∿ ▽	40(An_{22})**	28 α	Ap(ab), Chl, Op(2%), Zr(ab)

[1]See Appendix A for explanation of symbols used

Table 7. Visually estimated modal compositions of Mudjatik Domain felsic gneisses (Subunit MFc)[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
0055	Monzogranitic biotite gneiss	3 ×**		25	30(An_{18})**	41 ∝	Ap, Chl, Ms, Op(1%), Zr
0056	Monzogranitic biotite gneiss	4 ∿**		25 Δ	25(An_{29})**	46 ∞	Ap, Chl, Op, Zr
0057	Monzogranitic hornblende gneiss	Tr ×	3	30 ∿ Δ	30(An_{24})*	36 ∝	Ap, Op(1%), Zr
0058	Granodioritic biotite gneiss	6 — ×		25 —	58(An_{27}) ∝*	10	Ap, Op(1%), Zr
0059	Monzogranitic biotite gneiss	5 — ×**	Tr	40 ∿ Δ	25(An_{26})∝**	30 ∝	Ap(ab), Chl, Op, Zr(ab)
0062	Monzogranitic hornblende-biotite gneiss	5 — ×	1	30 ∿ ∇	25(An_{21})*	39 ×	Ap, Op(r), Zr
0066	Granodioritic biotite gneiss	4 — ×*		24 ∿	50(An_{23})∝*	20 ∝	Ap(ab), Chl, Ms, Op(2%), Sph(ab), Zr
0067	Monzogranitic biotite gneiss	4 — ×*		30 ∿	35(An_{21})*	30 ∝	Ap, Chl, Op(1%), Zr
0070	Monzogranitic biotite gneiss	7 — ×*		25 ∿	30(An_{21})∿ ∝*	38 ∿ ∝	Ap, Chl(r), Op(r), Zr
0073	Monzogranitic biotite gneiss	4 — ×**		30 — ∇	30(An_{18})***	35 ∝	Ap(r), Chl, Ms(r), Op (1%), Zr(r)
0074	Granodioritic biotite-hornblende gneiss	3 — ×	3	23 — ∇	60(An_{21})*	10	Ap, Op(1%), Sph, Zr(r)
0076	Monzogranitic biotite gneiss	4 ∿ ×*		40 ∿ ∇	30(An_{21})*	25 ∞	Ap, Chl, Op(1%), Zr(r)
0077	Quartz dioritic diopside-biotite gneiss	4 ∿ ×**		10	78(An_{24})∞ *	3	Ap(ab), Chl, Di(4%), Op(1%), Zr
0116	Tonalitic biotite gneiss	12 — ×***		33 — ∇	55(An_{30})***		Ap, Cbt, Chl(ab), Ep, Op, Zr

[1]See Appendix A for explanation of symbols used

Many sections (0055, 0070, 0077) show localized areas of polygonal granoblastic texture.

In **Subunit MFd** (Table 8), *biotite* is generally more abundant than in any of the other felsic gneisses. In section 0237, from the Cable Bay Shear Zone, it is highly chloritized and deformed, and is very light coloured with pale straw yellow to pale brown dichroism. *Hornblende*, abundant as xenoblastic grains 0.1 to 3.0 mm long, displays a pronounced parallel alignment in two specimens (0118, 0120). It is pleochroic in pale and moderate shades of brown, grass green and, in 0237, bluish sea green. In 0237, hornblende is considerably strained and is extensively altered to biotite and chlorite. *Quartz* characteristically shows preferred dimensional orientation, accompanied by straining and incipient grain-size breakdown; it is ribboned in 0237. *Plagioclase* (high oligoclase - low andesine) is more calcic than in any of the other felsic gneiss subunits and is slightly to extensively sericitized. In 0237 it occurs as rounded porphyroclasts, 0.5 to 1.5 mm in

Table 8. Visually estimated modal compositions of Mudjatik Domain felsic gneisses (Subunit MFd)[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
0065	Trondhjemitic biotite gneiss	7 — ×**		25	65(An_{24})∝*	3	Ap, Ch[illegible] Op, Zr
0111	Tonalitic hornblende-biotite gneiss	8 — ×	3	20 ∿ Δ	65(An_{28})∝*	3	Ap(ab), Op(1%), Zr(r)
0118	Tonalitic hornblende-biotite gneiss	8 — ×*	7 ∿*	20 — ∇	65(An_{28})∝*	Tr	Ap(ab), Chl, Op(r), Zr
0120	Tonalitic hornblende-biotite gneiss	5 — ×	5 ∿	25 — ∇	65(An_{35})*	Tr	Ap, Op(r), Zr(r)
0237	Tonalitic biotite-hornblende gneiss	3 Δ***	5 Δ***	30 — ∇	50(An_{39})***	2	Ap, Chl(7%), Ep, Op(3%), Sph, Zr

[1]See Appendix A for explanation of symbols used

diameter, which are quite strained and extensively altered. *Microcline*, a minor constituent of these rocks, typically forms ragged, amoeboid interstitial grains up to 0.75 mm in size. It shows mere hints of cross-hatching. *Accessory minerals* are similar to those found in rocks of Subunit MFa. *Alteration products*, mainly chlorite and sericite, are particularly abundant in 0237 along with epidote and sphene.

Equigranular and inequigranular polygonal and interlobate textures are equally common in samples from this subunit. Cataclastic textures such as granulation and ribboning of quartz, suturing of interquartz boundaries, and plagioclase porphyroclast formation are developed throughout 0237.

Waxy Felsic Gneisses (Units MwFC, MwFE)

The waxy reddish brown felsic gneisses (Unit MwFC, Tables 9a, b) are predominantly charnockitic, while the waxy greenish brown felsic gneisses (Unit MwFE, Table 10) are almost all enderbitic. Both have mineralogical compositions similar to the more common pink and grey felsic gneisses already described, the major difference being the presence of hypersthene and, especially in Unit MwFE, of diopside. Patches of yellowish brown biotite (probably pseudomorphous after orthopyroxene) occur in some samples.

In the **waxy reddish brown felsic gneisses** (Unit MwFC, Tables 9a, b), *biotite* is ubiquitous, commonly in only trace amounts, as partial to complete rims around opaque grains (0014, 0017, 0033, 0034, 0046, 0227, 0228) and/or as an alteration product of hypersthene (0033, 0034, 0194). Biotite, where forming several percent of the rock, normally occurs as well-oriented flakes 0.1 to 2.0 mm in length, but some randomly oriented flakes are invariably present. Three dichroic schemes have been observed. The commonest is from pale to moderate or dark brown, rarely with slight reddish tinges (0033, 0064). Where biotite has core remnants of hypersthene and is edged by opaques (0040), it is clearly an alteration product of hypersthene and is dichroic in varying shades of orange brown. In several sections (0040, 0228), flakes associated with opaque minerals are dichroic from pale straw yellow to green. *Hornblende* (<0.1 to 2.0 mm in size) is widespread and, unlike the hornblende in Subunit MFa, is usually fresh. It normally exceeds biotite when both minerals are present and, in places, is concentrated into well-defined laminations (0194, 0227). Grains are subidioblastic to idioblastic when enclosed in other minerals such as quartz (0017, 0039); elsewhere they are xenoblastic and range in size from less than 0.1 to 2.0 mm. The hornblende occasionally surrounds opaque grains as partial to complete rims (0014, 0039, 0046). It is pleochroic in pale to dark shades of brown and grass green, very rarely with blue tinges to the green (0183). *Hypersthene*, forming up to about 2 percent of the charnockitic gneisses, is almost always either partly or completely altered to a distinctive orange-brown biotite and, in some sections, to amphibole and opaques. The biotite thus produced itself appears to alter into an amorphous, non-pleochroic, yellow-brown mineraloid. Most hypersthene grains vary in size from 0.1 to 1.0 mm. They are xenoblastic and enclose apatite and/or biotite, opaques, plagioclase, quartz and zircon. Extremely pale pleochroism in pink and green is nearly always distinguishable. Diopside is fresher than orthopyroxene and tends to form larger grains (up to 2.5 mm).

Quartz grains are irregular in shape and vary in size from less than 0.1 to 6.0 mm or more. Preferred dimensional orientation is weakly developed in many thin sections; in a few cases the mineral shows intense undulose extinction. Incipient breakdown in grain size, commonly observed in quartz from most other rock types in the map area, was not seen in thin sections of this unit. *Plagioclase* occurs as irregularly shaped grains 0.1 to 4.0 mm in diameter; it is high oligoclase/low andesine in composition and is more calcic than that found in compositionally similar felsic gneisses (e.g. Subunit MFa) that lack both the waxy colour and hypersthene. In Unit MwFC, 27 percent of the thin sections show plagioclase compositions less than An_{25}, 46 percent are in the range An_{25-30} and 27 percent in the range An_{30-35}. Comparable percentages for Subunit MFa are 74, 21 and 5 percent, respectively. In grains larger than 2.0 mm, multiple twin lamellae are gently to considerably (0013, 0036) curved. In 3450, they are also slightly offset along fractures. Some crystals are moderately strained (0048). Plagioclase usually contains patches of exsolved microcline in at least a few of the large grains. Slight to moderate sericitization has affected the plagioclase in about one-third of the slides. *Microcline* grains are mostly 0.1 to 4.0 mm in diameter. Cross-hatched twinning is generally sharply developed, but is locally incipient (0033, 0048, 0155, 0194, 3470). In most slides, microcline contains fine string- or spindle-lamellae, blebs and/or patches of exsolved plagioclase. In places, it is lightly dusted by opaque material (3510).

Accessory minerals include ubiquitous apatite, opaques and zircon. Apatite is generally very plentiful (up to about 1 percent in 0034) as idioblastic (rare) to xenoblastic grains with a maximum dimension of 0.5 mm. Equidimensional opaque grains, 0.1 to 1.5 mm across, commonly make up about 1 percent of this rock type; they are mostly xenoblastic, but in places develop partial to

Table 9a. Visually estimated modal compositions of Mudjatik Domain waxy brown felsic gneisses (Unit MwFC)[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Pyroxene	Quartz	Plagioclase	Microcline	Accessory Minerals
0013	Charnockitic hypersthene-biotite gneiss	4 — ×		1(hyp)**	30 ∿	30(An_{28})∝	35 ∞	Ap(ab), Op, Zr
0014	Charnockitic hypersthene-hornblende gneiss	Tr	3	2(hyp)*	34 —	30(An_{21})∝	30 ∞	Ap, Op(1%), Zr
0017	Charnockitic hypersthene-hornblende gneiss	Tr	3	1(hyp)***	35 ∿	25(An_{25})∝	35 ∞	Ap, Op(1%), Zr
0027	Charnockitic hypersthene-biotite-hornblende gneiss	3 — ×	3	1(hyp)*	25 ∿	40(An_{31})∝	28 ∞	Ap(ab), Op, Zr
0028	Charnockitic biotite-hypersthene-hornblende gneiss	1 ∿ ×	3	2(hyp)*	30 —	39(An_{25})∝	25 ∞	Ap(ab), Op(ab), Zr
0033	Charnockitic diopside-hypersthene gneiss	Tr		5(hyp>di)**	20 ∿	40(An_{34})∝	35	Ap(ab), Op, Zr(r)
0034	Charnockitic hypersthene-hornblende gneiss	Tr ×	5	1(hyp)***	20 ∿	35(An_{33})∝	37 ∞	Ap(1%), Op(1%), Zr
0036	Charnockitic hypersthene-hornblende-biotite gneiss	3 ∿ ×	1	1(hyp+?di)**	30 ∿	30(An_{31})∝	34 ∝	Ap(ab), Op(1%), Zr
0037	Charnockitic hypersthene-biotite gneiss	2 ×		?hyp***	40	11(An_{23})∝**	45 ∞	Ap, Op(2%), Zr
0039	Charnockitic diopside-hypersthene-hornblende gneiss	Tr	3	3(3hyp:1di)**	20 ∿ Δ	30(An_{29})∝	43 ∞	Ap(ab), Op(1%), Zr
0040	Charnockitic hypersthene-biotite gneiss	1		1(hyp)***	30 Δ	20(An_{24})*	47 ∞	Ap, Op, Zr
0046	Charnockitic hypersthene gneiss	Tr	Tr	2(hyp)**	27 ∿ Δ	40(An_{28})∝	30 ∞	Ap(ab), Chl(r), Op(1%), Zr
0048	Charnockitic hypersthene-biotite gneiss	5 — ×		2(?hyp)****	28 ∿	35(An_{24})∝	30 ∝	Ap(ab), Cbt, Op, Zr(r)
0051	Charnockitic hypersthene-biotite gneiss	3 ∿		?hyp****	25 ∿ Δ	25(An_{30})∝*	46 ∞	Ap, Op(1%), Zr(ab)
0063	Charnoenderbitic diopside-hypersthene-biotite gneiss	3 — ×		1(2hyp:1di)**	30 ∿ Δ	51(An_{34})∝**	15 ∝	Ap, Op, Zr(r)
0064	Charnoenderbitic hypersthene-hornblende-biotite gneiss	5 — ×*	2	Tr(hyp)	38	45(An_{21})∞*	10	Ap, Chl, Op, Zr
0147	Charnockitic hypersthene-biotite-hornblende gneiss	4 ∿ Δ	6	?hyp****	20	35(An_{26})∝**	35 ∞	Ap(ab), Op, Zr(ab)
0155	Charnockitic hypersthene-biotite-hornblende gneiss	2 ×	5	2(hyp)***	25 Δ	35(An_{28})∝	30 ∞	Ap(ab), Gt, Op(1%), Zr
0183	Charnoenderbitic hypersthene-biotite-hornblende gneiss	3 —	6	? hyp***	30 ∿ Δ	40(An_{28})∝*	20 ∞	Ap(ab), Op(1%), Zr(ab)
0194	Charnockitic hypersthene-hornblende gneiss	Tr	3	?hyp****	35 — ∇	35(An_{30})∝	25 ∞	Ap(ab), Op(2%), Zr
0203	Charnockitic hypersthene-biotite gneiss	4 ×*		?hyp****	20	40(An_{29})∝**	35 ∞	Ap, Chl, Op(1%), Zr
0227	Charnockitic hypersthene-hornblende gneiss	Tr	5	?hyp****	24 ∇	45(An_{29})∝*	25 ∝	Ap(ab), Op(1%), Zr (ab)
0228	Charnockitic hypersthene-hornblende gneiss	Tr	4	1(hyp)***	20 ∇	40(An_{25})∝**	34 ∞	Ap(ab), Op(1%), Zr

[1]See Appendix A for explanation of symbols used

complete crystal outlines. Zircon grains are idioblastic (rare) to xenoblastic (rounded) and frequently show one or more overgrowth shells (0013, 0014, 0147, 0203, 0227); most are less than 0.2 mm in diameter, but they locally attain 0.5 mm (0155). A xenoblastic grain of garnet 2.5 mm across is present in 0155. Carbonate occurs in a thin, cross-cutting veinlet in sample 0048. *Alteration products* include chlorite (from biotite) and sericite (from plagioclase).

Table 9b. Visually estimated modal compositions of Mudjatik Domain waxy brown felsic gneisses (Unit MwFC) collected for radiometric dating[1]

Dept. No. (7818-)	Rock Name	Biotite	Hornblende	Pyroxene	Quartz	Plagioclase	Microcline	Accessory Minerals
3450	Charnockitic biotite-hypersthene gneiss	1 — ×		2(hyp)***	35	17(An_{24})	45 ∞	Ap, Op, Zr
3470	Charnoenderbitic hypersthene-biotite gneiss	2.5 ∿ ×		2.5(hyp)***	35	40(An_{25}) ∝	20	Ap, Op, Zr(r)
3510	Charnockitic hypersthene-biotite-hornblende gneiss	2 ∿	2	1(hyp)**	30	30(An_{23})*	35 ∝	Ap, Op, Zr

[1]See Appendix A for explanation of symbols used

Interlobate and polygonal granoblastic textures are well developed. The latter is found in both the equigranular and inequigranular varieties, whereas the former is predominantly inequigranular. Myrmekite is common. A characteristic feature of the gneisses of Unit MwFC is the presence of a pale yellow to red-brown amorphous mineraloid (serpentinous?) that coats felsic grains to a thickness of 0.1 mm and infills the tiny cracks which affect all of the mineral grains. The rock's friability and waxy reddish brown appearance are probably largely related to the presence of this coating/infilling material.

The **waxy greenish brown felsic gneisses** (Unit MwFE, Table 10) petrographically resemble the gneisses of Unit MwFC. *Hypersthene* is more abundant (commonly exceeding 2 percent) and is slightly coarser grained. Although usually disseminated throughout the rock (0038, 0047, 0049), it is locally concentrated into laminae (0052). Like the hypersthene contained in rocks of Unit MwFC, it is almost invariably weakly to very extensively altered to orange-brown biotite and/or an orange-brown amorphous (serpentinous?) mineraloid, amphibole (0050, 0069, 0217) and chlorite (0029, 0042, 0043). *Diopside* is more common than in gneisses of Unit MwFC, and is present in almost two-thirds of the representative sections. However, only in one instance does it exceed orthopyroxene in amount. *Plagioclase* is high oligoclase/low andesine and is thus more calcic than that contained in gneisses of Unit MwFC. All compositions are greater than An_{25}; 14 percent of the slides have compositions lying in the range An_{25-30}, 33 percent in the range An_{30-35}, 43 percent in the range An_{35-40} and 10 percent in the range An_{40-45}. Pericline twinning, in addition to the ubiquitous and dominant albite twinning, is more common. Exsolution lamellae and blebs of microcline are present in some of the large plagioclase grains; in addition, patch-like antiperthite is widely developed. *Microcline*, generally making up less than 5 percent of these gneisses, typically occurs as clear interstitial grains (less than 0.5 mm in size) and as an exsolved phase in plagioclase. Ubiquitous *accessory minerals* include apatite (plentiful), opaques (up to 1 percent) and zircon (rare). The latter, unlike the zircons found in Unit MwFC, completely lack overgrowths. Muscovite is spatially associated with biotite in one section (0042). Chlorite and sericite are present in some sections as alteration products of biotite and plagioclase respectively.

Inequigranular interlobate granoblastic textures are dominant, but almost 50 percent of the samples show locally developed equigranular and inequigranular polygonal granoblastic textures. Myrmekite is very rare.

Metamorphosed Intrusive Rocks (Units MFT, MFG, MFM)

The final three tectonized felsic rock units in the Mudjatik Domain are the metatrondhjemites and metatonalites of Unit MFT, metagranodiorites of Unit MFG and megacrystic metamonzogranites of Unit MFM.

In the **metatrondhjemites, metatonalites and metagranodiorites** of Units MFT and MFG (Table 11), *biotite* is more abundant than in the other felsic gneisses. Biotite flakes (less than 0.1 to 2.0 mm long) define an early fabric that is deformed in several samples taken from close to the Cable Bay Shear Zone (0123, 0125, 0126). Here, flakes are granulated, strained, bent and/or kinked, and show exceptionally ragged terminations. In 0123, some flakes are arranged parallel to the axial planes of the later microfolds. In most thin sections, a few flakes appear to be randomly oriented. Biotite is dichroic from pale brown or, less commonly, pale straw yellow to moderate or dark brown (rarely to green). In places, it is slightly altered to chlorite. *Hornblende*, if present, is usually moderately to completely (0126) altered to biotite and/or chlorite, sphene, opaques and epidote. Xenoblastic grains are generally 0.1 to 1.0 mm long, and are pleochroic in pale shades of brown and pale or moderate shades of grass green and bluish green (no blue tinges seen in 0083, 0179).

Table 10. Visually estimated modal compositions of Mudjatik Domain waxy greenish brown felsic gneisses (Unit MwFE)[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Pyroxene	Quartz	Plagioclase	Microcline	Accessory Minerals
0029	Charnoenderbitic hypersthene-diopside-biotite gneiss	5 — ×		5(1hyp:3di)	25 — V	55(An_{39})	10	Ap, Chl, Op(ab), Zr
0031	Enderbitic hypersthene-diopside-biotite hornblende gneiss	1 — ×	6	Tr(?hyp+di)***	30 ∿	59(An_{28}) ∝	3	Ap(ab), Op(1%), Zr
0035	Enderbitic hypersthene-diopside-biotite-hornblende gneiss	2 ∿ ×	5	3(1?hyp:1di)***	24 ∿	65(An_{38}) ∝		Ap(ab), Op(1%), Zr
0038	Enderbitic diopside-biotite-hypersthene gneiss	2 — ×		4(hyp+?di)	20 — Δ	72(An_{34}) ∞	2	Ap, Op(r), Zr(r)
0041	Enderbitic hypersthene-biotite gneiss	5 ×	Tr	1(?hyp)****	25	63(An_{26}) ∝	5	Ap(ab), Op(1%), Zr(r)
0042	Charnoenderbitic hypersthene-biotite gneiss	5 — ×*		Tr?hyp****	25 — Δ	50(An_{33}) ∝**	20	Ap(r), Chl, Ms, Op (r), Zr
0043	Charnoenderbitic hypersthene-biotite gneiss	3 ∿		Tr?hyp****	35 — Δ	50(An_{31}) ∝	10*	Ap, Chl(2%), Op(r), Zr(r)
0044	Charnoenderbitic hypersthene-diopside-biotite gneiss	4 ×*		4(1hyp:1di)**	25 ∿ Δ	60(An_{27}) ∝*	7 ∝	Ap(ab), Op, Zr(r)
0047	Plagioclasitic pyroxene-bearing gneiss	Tr ×		6(1hyp:1di)	6	85(An_{42}) ∞	2	Ap, Op(1%), Zr(r)
0049	Enderbitic biotite-hypersthene gneiss	2 ∿ ×		5(hyp)*	20 Δ	70(An_{37})	1	Ap(ab), Op(2%), Zr
0050	Plagioclasitic diopside-hornblende-hypersthene gneiss	Tr	3	5(hyp+?di)*	15	75(An_{36}) ∞	1	Ap(ab), Op(1%), Zr (r)
0052	Enderbitic hypersthene-diopside-biotite hornblende gneiss	3 — ×	3	1(1hyp:1di)*	30 ∿	62(An_{34}) ∝	1	Ap(ab), Op, Zr(r)
0053	Plagioclasitic diopside-hypersthene-biotite-hornblende gneiss	2 ×	2	3(3 hyp: 2di)**	12	80(An_{30})*	Tr	Ap(ab), Op(1%), Zr(ab)
0054	Enderbitic diopside-hornblende-biotite-hypersthene gneiss	3 ∿ ×	2	4(5hyp:1di)*	27 ∿	63(An_{34}) ∝*	Tr	Ap, Op(1%), Zr(r)
0069	Enderbitic hypersthene-biotite gneiss	4 — ×	Tr*	2(hyp)*	34 —	55(An_{41}) ∝	5	Ap(ab), Chl, Op, Zr
0072	Enderbitic diopside-biotite-hornblende-hypersthene-gneiss	1 ×	2	3(6hyp:1di)	30 Δ	63(An_{37}) ∞	Tr	Ap, Op(1%), Zr
0079	Enderbitic hypersthene-biotite gneiss	4 — ×		1(hyp)**	35 ∿	60(An_{35}) ∝	Tr	Ap, Op, Zr(r)
0084	Enderbitic hypersthene-biotite gneiss	2 — ×		2(hyp)	20 ∿ Δ	75(An_{37}) ∝*	Tr	Ap, Chl, Op(1%), Zr
0085	Enderbitic diopside-hypersthene-hornblende gneiss	Tr ×***	3	2(6hyp:1di)	24	70(An_{37}) ∞*	Tr	Ap(ab), Chl, Op(1%), Zr
0150	Enderbitic diopside-hypersthene-biotite gneiss	10 — ×	Tr	10(6hyp:4di)***	20 ∿	60(An_{39})		Ap, Op(ab), Zr(r)
0217	Charnoenderbitic hypersthene-biotite gneiss	5 ×	1	1(hyp)*	35 Δ	50(An_{30}) ∞*	8 ∞	Ap(ab), Op, Zr(ab)

[1]See Appendix A for explanation of symbols used

Quartz (0.1 to 5.0 mm in size) commonly exhibits a preferred dimensional orientation and shows extreme undulose extinction in many slides. In some, it is granulated and/or incipiently ribboned (0082, 0123, 0124, 0125, 0126, 0156). *Plagioclase* is oligoclase/andesine and varies in composition from An_{21} to An_{43}. Grains are 0.1 to 4.0 mm across. Rarely, they are normally zoned (0156). Some contain antiperthitic microcline in the form of lamellae, blebs or patches. Albite twinning is ubiquitous, and is locally accompanied by pericline twinning; lamellae are sometimes slightly curved and strained. In 0125 and 0126, plagioclase grains are augen-shaped, surrounded by ribboned quartz and show extremely bent or kinked twin lamellae. Slight to moderate sericitization affects the mineral in most sections.

Table 11. Visually estimated modal compositions of Mudjatik Domain metatrondhjemites and metatonalites (Unit MFT) and metagranodiorites (Unit MFG)[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
0082	Weakly foliated hornblende-biotite metatrondhjemite	3 ∿*	1**	30 — ∇	65(An_{21}) ∝**	1	Ap, Chl, Op, Zr
0083	Well-foliated biotite metatrondhjemite	6 — ×	Tr**	27 —	65(An_{31}) ∝*	1	Ap(ab), Op(1%), Zr
0086	Weakly foliated biotite metagranodiorite	5 ×		25 Δ	60(An_{22}) ∞**	10 ∝	Ap, Op, Zr(r)
0087	Weakly foliated biotite metagranodiorite	5 ×		25 Δ	50(An_{21}) ∝*	20 ∝	Ap, Op(ab), Sph, Zr
0123	Well-foliated biotite-hornblende metatonalite	8 ∿ ≃	8	40 — ∇	44(An_{39})*	Tr	Ap(ab), Ep(?), Ms(?), Op(r), Zr
0124	Weakly foliated biotite-hornblende metatonalite	7 ×*	8	20 — ∇	65(An_{43})**		Ap(ab), Chl, Op, Sph (ab), Zr(r)
0125	Intensely lineated biotite-hornblende metatonalite	8 — Λ	12**	40 — ∇	40(An_{38})*∝ Δ	Tr	Ap, Ep, Op, Sph, Zr(r)
0126	Intensely lineated biotite metatonalite	22 — Λ ×	?****	30 — ∇	45(An_{33}) Δ		Ap, Ep(3%), Op(r), Zr
0156	Weakly foliated biotite meta-quartz diorite	20 — ×		12 ∇	68(An_{36})*		Ap(ab), Ep, Op, Zr
0178	Well-foliated biotite metamonzogranite	10 — ×*		30 ∿ ∇	30(An_{24}) ∝*	30 ∝	Ap(ab), Chl, Ms, Op(r), Zr
0179	Well foliated hornblende-biotite metamonzogranodiorite	10 — ×*	1**	30 — Δ	39(An_{32})	20 ∝	Ap, Chl, Ms, Op, Zr

[1]See Appendix A for explanation of symbols used

The content of *microcline* is highly variable. Where the content is extremely low, the mineral occurs as interstitial grains up to 0.3 mm across and/or as exsolved material in plagioclase. Where abundant, grains are up to 2.0 mm across, are clearly cross-hatched and are weakly microperthitic.

Apatite (abundant), opaques and zircon are ubiquitous *accessory minerals*. Rare multiple overgrowth was observed in a few zircon crystals in 0156. Opaque grains tend to be small, and are less than 0.5 mm across in 0083, 0123, 0124, 0125, 0126, and 0178 (opaque dust). Muscovite is present in two thin sections (0178, 0179) as ragged interstitial grains up to 0.5 mm long and as overgrowths on biotite terminations. Rare idioblasts of probable monazite, up to 0.3 mm across, occur as overgrowths on an earlier, commonly metamict monazite. *Alteration products* include sphene, chlorite, epidote and sericite.

Cataclastic textures such as granulated or ribboned quartz, sutured interquartz boundaries, and augened plagioclase grains are common. Elsewhere, inequigranular interlobate granoblastic textures are dominant. Myrmekite was found only in 0087.

In the **megacrystic metamonzogranites** of Unit MFM (Table 12), *biotite* is weakly to randomly oriented. Flakes are usually less than 2.0 mm long, and are dichroic from pale to moderate or, more commonly, dark brown. *Ferrohastingsite*, pleochroic in moderate shades of brown and dark shades of green, is characteristic of these intrusives. In 0127, some crystals have a marginally developed bluish green amphibole. Grains range in size from 0.1 to 2.5 mm.

Quartz generally exhibits preferred dimensional orientation, very intense straining and, in one specimen (0096), incipient granulation. Crystals range from 0.1 to 7.0 mm across. *Plagioclase* (oligoclase) is compositionally homogeneous (An_{21-23}), except for locally developed, partial rimming by clear albite in thin section 0095. Grains range from 0.1 to 5.0 mm in size and enclose apatite, biotite, ferrohastingsite, quartz, zircon and microcline; the microcline occurs both as exsolved material and as inclusions of an initially separate mineral phase. Plagioclase is everywhere moderately sericitized. *Microcline* xenoblasts, 0.1 to 4.5 mm in diameter, are superbly cross-hatched. They enclose apatite and/or biotite, opaques and plagioclase; the plagioclase occurs as string lamellae, fine to coarse spindle lamellae, marginally developed flame-like wedges or albite-rimmed patches (0096, 0127).

Accessory minerals include apatite (abundant), opaques (about 1 percent) and zircon, together with subordinate sphene, muscovite and epidote. Apatite occurs as subidioblastic to xenoblastic crystals up to

Table 12. Visually estimated modal compositions of Mudjatik Domain megacrystic metamonzogranite and compositionally similar rock types (Unit MFM)[1]

Dept. No. (7708-)	Rock Name	Biotite	Ferrohastingsite	Quartz	Plagioclase	Microcline	Accessory Minerals
0095	Well-foliated biotite-amphibole metamonzogranite	4 ∿ ×	4*	27 ∿ ▽	35(An_{21})α**	30 α	Ap, Op(r), Sph(r), Zr
0096	Well-foliated biotite-amphibole meta-quartz monzonite	4 ∿ ×	4	17 — ▽	40(An_{21})α**	35 ∞	Ap(ab), Op, Sph, Zr
0099	Well-foliated biotite meta-quartz syenite	6 — ×*		18 ▽	25(An_{21})α**	50 ∞	Ap(ab), Chl, Op(1%), Zr(ab)
0119	Well-lineated biotite metamonzogranite	10 ×	Tr	24 ∿ ▽	30(An_{23})α**	35 α	Ap(ab), Ms, Op(1%), Zr(r)
0127	Well-foliated biotite-amphibole metamonzogranite	4 ×	6	29 — ▽	30(An_{21})α**	30 α	Ap, Ep, Op(1%), Sph (r), Zr(r)

[1]See Appendix A for explanation of symbols used

0.5 mm across. Equidimensional opaque grains attain diameters of about 1.0 mm. They are irregularly shaped or, rarely, show partially developed crystal faces. In places, they are rimmed by sphene (0096). Zircon idioblasts (0095, 0096) and xenoblasts (0099, 0127) reach lengths of 0.4 mm. Single and multiple overgrowth shells are common in one section (0119) but have not been recorded from elsewhere. Xenoblastic sphene up to 0.7 mm across, where present, shows a notable spatial association with biotite and/or hornblende. Muscovite (0119) is also spatially relatd to biotite. Epidote forms granular aggregates in 0127. *Alteration products* include sericite (from plagioclase), chlorite (from biotite) and biotite (from amphibole). Patches up to 1.5 mm across of a yellowish brown to dark brown, non-pleochroic amorphous secondary material are widespread (0095, 0096, 0119).

Inequigranular interlobate granoblastic textures are common; polygonization is also locally present (0096, 0099 and 0127). Myrmekite is widely developed.

Amphibole Gneisses (Unit MA)

Most of the 14 specimens of amphibole gneisses (Unit MA) from the Mudjatik Domain (Table 13) contain hornblende, hypersthene and diopside. In several thin sections, many *biotite* flakes (0.1 to 2.5 mm long) are poorly to well aligned, although a few are randomly oriented. They are dichroic from pale straw yellow (rare) or pale brown to moderate or dark shades of brown or reddish brown (0180, 0195. 0202, 0204). They are locally interleaved with muscovite (0180), or partially surround opaque grains (0202). *Hornblende*, the dominant mafic mineral in most sections, generally shows a random orientation. It is pleochroic in pale shades of brown or, rarely, straw yellow (0230, 0231) to moderate shades of greenish brown (0220, 0221, 0224) grass green and/or sea green (0149, 0230, 0231). Most grains are xenoblastic and less than 3.0 mm across.

Several generations of hornblende are apparently present; early, highly strained, locally granulated porphyroblasts about 5 mm long are cut and replaced by smaller idioblastic and subidioblastic grains. *Hypersthene* is commonly altered to hornblende (0189, 0202, 0224), to pale brown or orange-brown biotite (0189, 0202, 0204), or to a yellow-brown non-pleochroic amorphous (possibly serpentinous) mineraloid (0149, 0204). Where fresh, it is generally pleochroic in pale shades of pink and green. Grains are mostly less than 2.0 mm in size but can locally form 7.0 mm long porphyroblasts (0201). In places, they are schillerized (0184). *Diopside* is more abundant than the orthopyroxene and in places is slightly altered to amphibole, carbonate and an orange-brown non-pleochroic amorphous material. Grains are moderately poikiloblastic, enclosing apatite and/or hornblende, opaques and plagioclase, and are normally less than 3.0 mm across.

Quartz is present in only a few sections, generally as inclusions in other minerals (0189, 0202, 0204) or as interstitial grains (0189, 0204). In 0115 (5 percent) it is evenly distributed throughout the rock as slightly strained equidimensional grains enclosing plagioclase and varying in size from 0.1 to 3.0 mm. In sample 0180, it is concentrated in coarse-grained felsic layers as crystals up to 5.0 mm across. These are highly strained and some grains show incipient granulation. *Plagioclase* (andesine/labradorite) varies from An_{36} to An_{68}. Some grains are normally zoned (0224, 0230, 0231). Sharp albite twinning and, in some slides (0115, 0201, 0202, 0220, 0221), pericline twinning are well developed. Twin lamellae are occasionally either gently (0115, 0201, 0204) or strongly (0184) curved. Plagioclase grains are normally less than 2.5 mm across and frequently show slight to extensive sericitization (0115, 0149, 0202), saussuritization (0180, 0189, 0230, 0231) or chloritization (0184).

Equigranular polygonal granoblastic textures are common (0115, 0149, 0180, 0201, 0221), together

Table 13. Visually estimated modal compositions of Mudjatik Domain mafic gneisses (Unit MA)[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Hypersthene	Diopside	Quartz	Plagioclase	Accessory Minerals
0115	Pyriclasite	Tr – ×*		5	30	5	58(An_{46})*	Ap(ab), Chl, Op(2%), Zr(r)
0149	Hornblende pyriclasite		20	Tr***	20		60(An_{68})*	Ap(r), Op(r)
0180	Quartz-bearing amphibolite	5 ∿ ×*	45		10 Δ		40(An_{48})***	Ap(ab), Chl, Ms, Op, Sph
0184	Pyroxene amphibolite	2 ∿ ×	37 ∿	4***	16		40(An_{36})***	Ap(ab), Chl, Op(1%), Zr(r)
0189	Hornblende pyriclasite	1 ×	10	9*	9*	Tr	70(An_{42})*	Ap(ab), Op(1%), Zr(r)
0195	Pyroxene amphibolite	2 ×	45	6	12*		35(An_{60})	Ap(r), Op
0201	Hornblende pyriclasite		15 ∿	5	25		50(An_{63})	Ap(ab), Op(5%), Zr(r)
0202	Hornblende pyriclasite	Tr	10 ∿	10**	15*	Tr	60(An_{57})*	Ap(ab), Op(5%), Zr(ab)
0204	Pyroxene amphibolite	5 – ×	25 ∿	1**	9*		60(An_{42})	Ap(ab), Op(r), Zr(r)
0220	Pyroxene amphibolite		34		10	1	55(An_{45})	Ap(ab), Op
0221	Hornblende pyriclasite		15	25	8		50(An_{64})	Ap, Op(1%)
0224	Hornblende pyriclasite		25	5**	25***		45(An_{64})	Ap(r), Cbt, Op, Zr(r)
0230	Amphibolite		60 ∇				38(An_{54})**	Ap(ab), Cbt, Chl, Op(2%), Zr(r)
0231	Amphibolite	Tr*	63 ∇				35(An_{50})**	Ap, Op(2%)

[1] See Appendix A for explanation of symbols used

with, in some thin sections, equigranular interlobate granoblastic textures (0189, 0195, 0202, 0220). Two slides (0230 and 0231, both collected from within 1 km of the southwestern extension of the Cable Bay Shear Zone) exhibit an inequigranular polygonal granoblastic texture; 0231 also displays granulation of hornblende porphyroblasts. Only one thin section (0204) has an inequigranular interlobate texture developed throughout.

Metasediments (Units MP, MSP, MPS, MQ)

Table 14a presents the visually estimated modal compositions of 9 pelites (Unit MP). Apart from feldspar, cordierite is generally the dominant aluminous mineral, with sillimanite generally comprising several percent of the rock. Quartz normally forms less than 20 percent. The modes of 11 semipelites (Unit MSP) are shown in Table 14b. The biotite content usually exceeds that of cordierite. Sillimanite, where present, is frequently enclosed in trace amounts within other minerals. Quartz generally constitutes more than 20 percent of the rock. Psammites (Unit MPS, Table 14c) and quartzites (Unit MQ, Table 14d) contain much less cordierite, biotite and, generally, feldspar than the other rock types. Trace amounts of sillimanite occur as tiny needles within quartz. Unlike the feisic rocks of the Mudjatik Domain, apatite is rare as an accessory in the metasediments.

Biotite, although ubiquitous in the metasediments, often occurs in low concentrations (less than 3 percent in 13 of the 27 slides). Most flakes are less than 2.0 mm long and define a weak to strong preferred orientation, although at least a few in the majority of slides are transversely oriented. In the pelites, dichroic colours are variable but are mostly from pale to moderate or dark shades of brown (tinged by red in 0151, 0185, 0187). The abundance of haloes is also variable; rare in specimen 0192, they are moderately common in most other slides, except 0152 where they are very abundant. The biotite flakes in 0152 are much larger than elsewhere, attaining lengths of about 6.0 mm; they poikiloblastically enclose cordierite, opaques and sillimanite. In sample 0151, they are mimetically recrystallized around a fold hinge. Biotite in both the pelites and the semipelites is usually petrographically similar, except that a higher proportion of the semipelite slides contains flakes with reddish brown colours (0188, 0190, 0191, 0198, 0219, 0223). In the psammites and quartzites, however, biotite tends to be paler in colour, typically from pale straw yellow or brown to moderate brown. Haloes are usually rare. Two generations of biotite, both interleaved with muscovite, are distinguishable in places (0176); the earlier generation has normal dichroism, while the later one varies from very pale straw yellow to pale green.

Table 14a. Visually estimated modal compositions of Mudjatik Domain pelitic gneisses (Unit MP)[1]

Dept. No. (7708-)	Rock Name	Biotite	Garnet	Cordierite	Sillimanite	Spinel	Quartz	Plagioclase	Microcline	Accessory Minerals
0151[2]	Pelitic sillimanite-garnet-biotite-cordierite gneiss	7 — ×	20 ○	10 — ○**	1 —		30 ∿ Δ	20(An_{36})	30 ∝	Gr(?), Op, Zr
0152	Pelitic sillimanite-garnet-biotite-cordierite gneiss	10 ∿ ×	4	12 ○**	4 ∿ ×		10 ▽	45(An_{35})	15 ∞	Ms(r), Op, Sph(r), Zr
0157	Pelitic chlorite-biotite gneiss	25 ∿ ×					50 ▽			Ap(ab), Chl(25%), Op (r), Zr(r)
0177	Pelitic biotite-sillimanite gneiss	8 ∿ ×*			30 —		15 Δ	35(An_{26})*		Ap(r), Chl, Ms(2%), Op(10%),Zr
0185	Pelitic spinel-biotite-sillimanite-cordierite gneiss	1		35 ○**	2 ∿ (in Co, Pl)	1	6 Δ	20(An_{37})	30 ∞	Op(5%), Zr
0187[2]	Pelitic biotite-sillimanite-garnet-cordierite gneiss	2 ∿ ×	8 θ	20 ○*	5		10 ∿	55(An_{38})*		Gr(?), Op(ab), Zr
0192[2]	Pelitic spinel-biotite-garnet-cordierite gneiss	2 ∿ ×	5 θ	30 — ○*	5	Tr	10	33(An_{37})	13	Gr(?), Op(2%), Zr
0200	Pelitic sillimanite-cordierite gneiss	Tr — ×	Tr ∿ θ	27 — θ*	3 — ×		33	5(An_{39})	32 ∞	Ap(r), Op(1%), Zr
0222	Pelitic biotite-garnet-sillimanite-spinel-cordierite gneiss	1 —	2	30 — θ	3 —	5 —	20 ∿	9(An_{26}) ∿	30 ∿ ∞	Op, Zr(ab)

[1]See Appendix A for explanation of symbols used

[2]Submitted to P. A. Nielsen for quantitative pressure/temperature studies

Garnet, common in pelites, semipelites and psammites, was not found in the quartzites. Most grains are xenoblastic and vary from 0.3 to 6.0 mm in size. A few dimensionally oriented grains are present in several sections (0186, 0196, 0200). They almost invariably contain inclusions, mainly of biotite, opaques, plagioclase, quartz and sillimanite. The prismatic minerals, especially sillimanite, define an internal schistosity in many sections (0192, 0196, 0201). Although this fabric generally parallels the external schistosity, in some samples (0187, 0191) it trends obliquely. Rarely, inclusions are more concentrated in the garnet cores than in marginal zones (0191). Garnet forms a rim around spinel in two thin sections (0196, 0222); in the latter, several grains of spinel are surrounded by cordierite which is overgrown by garnet.

Cordierite and its alteration product, pinite, occur in rocks belonging to all four metasedimentary units. Where it forms more than 10 percent of the rock, it poikiloblastically encloses many other minerals,

Table 14b. Visually estimated modal compositions of Mudjatik Domain semipelitic gneisses (Unit MSP)[1]

Dept. No. (7708-)	Rock Name	Biotite	Garnet	Cordierite	Sillimanite	Spinel	Hypersthene	Quartz	Plagioclase	Microcline	Accessory Minerals
0186	Semipelitic garnet-biotite gneiss	12 — ×	3 ○		Tr (in Gt, Qz)			25	40(An_{43})	20 ∝	Op(r), Zr
0188	Semipelitic hypersthene-biotite-garnet gneiss	9 — ×	11 θ				2*	40 ▽	38(An_{38}) ∝	Tr	Ap(r), Gr
0190	Semipelitic graphite-cordierite-garnet-biotite gneiss	8 ∿ ×	4 θ	2**	Tr(in Gt, Qz, Pl)			25 ∿ Δ	25(An_{37})*	35 ∞	Gr(1%), Op(r), Sph(r), Zr
0191[2]	Semipelitic graphite-garnet-biotite gneiss	11 ∿ ×	7 ○	Tr**	Tr(in Bt, Gt, Qz, Pl)			20 ▽	50(An_{38})	10	Gr(2%), Op, Zr(ab)
0193	Semipelitic biotite-cordierite gneiss	7 ∿ ×		10 ○**	Tr(in Qz)			53 ∿ ▽	30(An_{28}) ∝	Tr	Gr(?), Op(1%), Zr(ab)
0196	Semipelitic biotite-spinel-garnet-sillimanite-cordierite gneiss	1 ∿	2 ∿ θ	15 ○*	4 ∿	2		15 Δ	6(An_{23})	55 ∞	Gr(?), Op, Zr
0197	Semipelitic biotite gneiss	20 — ×***						35 ∿ ▽	25(An_{28})**	20 ∝	Ap(ab), Chl, Op, To(r), Zr(r)
0198	Semipelitic spinel-biotite-sillimanite gneiss	3 — ×	7 ○		3	Tr		15 ∿ ▽	15(An_{26})*	57 ∞	Op(ab), Sph(r), Zr(ab)
0219	Semipelitic graphite-hypersthene-biotite gneiss	14 —	Tr θ				5	30 ∿	50(An_{38})	Tr	Ap(r), Gr(1%), Zr
0223	Semipelitic sillimanite-biotite gneiss	5 — ×			5 ×			60 Δ		30 ∝*	Op, Zr(r)
0225	Semipelitic sillimanite-garnet-biotite-cordierite gneiss	3 — ×	3 ○	10 — ○**	1(in Bt, Co, Gt, Qz			30	23(An_{41}) ∝	30 ∞	Ap(r), Op(ab), Zr(ab)

[1]See Appendix A for explanation of symbols used

[2]Submitted to P. A. Nielsen for quantitative pressure/temperature studies

Table 14c. Visually estimated modal compositions of Mudjatik Domain psammitic gneisses (Unit MPS)[1]

Dept. No. (7708-)	Rock Name	Biotite	Garnet	Cordierite	Sillimanite	Quartz	Plagioclase	Microcline	Accessory Minerals
0148	Psammitic garnet gneiss	Tr	7 o*		?(in Qz)	60 ∇	2****	30 ∞	Ap(ab), Chl, Op(1%), Sph, Zr(ab)
0176	Psammitic cordierite-biotite gneiss	4 ∿ ×		2***	Tr(much in Qz)*	70	10(An_9)	13 ∞	Ms(1%), Op(r), Zr(r)
0199	Psammitic biotite gneiss	8 — ×*				67 — ∇	Tr***	25 ∞	Chl, Op, Zr(r)
0226	Psammitic garnet gneiss	Tr***	5 o		?(in Qz)	30	50(An_{42})∝**	15 ∝	Ap(r), Chl, Ms(r), Op(ab), Zr(ab)

[1]See Appendix A for explanation of symbols used

including biotite, garnet, quartz, sillimanite and zircon. Bright yellow to colourless pleochroic haloes are often developed around the zircon (0152, 0192, 0193, 0200, 0222, 0225). In several thin sections (0200, 0222), the preferred orientation of sillimanite enclosed in the cordierite defines an internal schistosity which parallels the external schistosity. Dusting by minute opaque granules gives cordierite a diagnostic cloudy appearance which, with its yellow haloes, its widespread alteration to pinite, and its indistinct lamellar twinning, enables it to be readily distinguished from co-existent plagioclase. Grains are generally less than 4.0 mm in length, and are locally elongated parallel to the biotite preferred orientation. In sample 0196, cordierite has a rim of plagioclase up to 0.3 mm wide separating it from adjacent microcline; in sample 0222, microcline or plagioclase normally separates quartz from cordierite.

Widespread *sillimanite* generally forms less than 5 percent of the rock. Where present in greater than trace quantities, it forms prisms 0.2 to 1.0 mm in diameter and up to 1.2 mm long. In two thin sections (0177 and 0192), two varieties of sillimanite are present: in 0177, an early generation of fibrolite is followed by later parallel prisms; in 0192, early, well-oriented small needles within cordierite and garnet define a planar fabric locally oblique to the external planar fabric partly defined by intergranular concentrations of later, larger sillimanite crystals. Where present in trace amounts, sillimanite occurs as minute needles (less than 0.05 mm long) that are usually too small to identify with certainty; these occur within quartz and are well oriented, apparently parallel to the quartz c-axis, garnet, plagioclase, cordierite and/or biotite.

Spinel (hercynite) occurs in five specimens (three pelites, two semipelites) as very dark green xenoblasts up to 8.0 mm long, skeletally intergrown with or enclosed by surrounding opaque minerals.

Hypersthene, present in some semipelites, forms slightly pleochroic xenoblastic grains 0.05 to 0.5 mm in diametr. Locally, much larger grains (2.0 mm) poikiloblastically enclose apatite, plagioclase and quartz.

Quartz commonly shows strongly developed undulose extinction in each of the four metasedimentary units, and also incipient granulation (0148, 0157, 0174, 0181, 0187, 0191, 0197, 0198). Grains vary in size but are normally less than 5.0 mm in diameter. Preferred dimensional orientation occurs in about one-third of the thin sections. In sample 0157, fractured quartz grains are infilled with chlorite.

In most of the metasediments, *plagioclase* grains range from less than 0.1 to 3.0 mm in size and are oligoclase/andesine. However, the most quartzitic rocks (70 percent or more quartz) contain small amounts of albite (0174, 0175, 0176). Of the 19 samples that contain oligoclase/andesine, 5 percent have compositions in the range An_{20-25}, 26 percent in the range An_{25-30}, 53 percent in the range An_{35-40} and 16 percent in the range An_{40-45}. The feldspar thus tends to be more calcic than it is in the charnockitic gneisses (Unit MwFC), and is compositionally similar to plagioclase in the enderbitic gneisses (Unit MwFE). It is usually fresh in the pelites and semipelites but moderately to completely sericitized in most psammites and quartzites. Albite twinning is very common, along with pericline twinning in many

Table 14d. Visually estimated modal compositions of Mudjatik Domain quartzites (Unit MQ)[1]

Dept. No. (7708-)	Rock Name	Biotite	Muscovite	Cordierite	Sillimanite	Quartz	Plagioclase	Microcline	Accessory Minerals
0174	Biotite-muscovite quartzite	2 ×*	6 ×		?(in Qz)	88 Δ	4(An_5)**		Chl, Op(r), Zr(r)
0175	Biotite-cordierite quartzite	2 — ×**	1 ×	?13****	?(in Qz)	80 Δ	2(An_{12})	Tr	Chl, Op(2%), Zr
0181	Biotite-muscovite quartzite	3 — ×*	3 ×			92 ∿ ∇	2***		Ap, Cbt, Chl, Op(r), Zr

[1]See Appendix A for explanation of symbols used

slides (0151, 0152, 0186, 0188, 0191, 0219, 0225, 0226). Gentle bending of lamellae is rare (0190, 0226). Normal compositional zoning was observed in sample 0222. Normal zoning may also be present in sample 0196, which contains only about 6 percent fractured, corroded plagioclase.

Microcline is normally microperthitic when it exceeds 15 percent of the rock. Grains are characteristically about 0.1 to 2.0 mm across. In addition to exsolved plagioclase, microcline encloses biotite and/or cordierite, opaques, quartz, sillimanite and zircon.

Accessory minerals are many and varied, but those most consistently present are opaques and zircon. The former, excluding graphite, generally form equidimensional xenoblastic to subidioblastic grains which range from less than 0.05 mm to 1.0 mm across and are rimmed by and/or complexly intergrown with spinel in all of the spinel-bearing samples. Zircon crystals are normally rounded and less than 0.1 mm in diameter, but rare idioblasts are present in a few sections (0174, 0181, 0225). Concentric overgrowths are also rare (0148, 0176, 0200, 0222). Apatite has been recognized, in small amounts, in only about 40 percent of the metasediments examined. Its sparsity here contrasts markedly with its abundance in other Mudjatik Domain rock types. Graphite occurs as flake-like grains up to 2.0 mm long, often situated along cleavage planes of biotite. Rare late randomly oriented muscovite flakes up to 3.0 mm long, an alteration product of sillimanite (0176), overgrow plagioclase and biotite, and also cut across the biotite. Sphene, which is also rare, either surrounds (0148) or occurs as granular aggregates close to (0152, 0190, 0198) opaque grains. Although tourmaline has been found in one sample, it is notably lacking in the metasediments. This contrasts markedly with its abundance in rocks of the Wollaston Group.

The most widespread *alteration products* are yellowish pinite, sericite and chlorite (which comprises up to 25 percent of some rocks). Carbonate, possibly after plagioclase, forms interstitial grains up to 0.4 mm across in sample 0181.

Inequigranular granoblastic textures occur in about 50 percent of the samples and, in half of these, polygonization is patchily developed. Equigranular polygonal and equigranular interlobate granoblastic textures are each developed in about a quarter of the 26 representative metasedimentary samples.

Leucogranite (Unit MG)

Massive leucogranites and other compositionally similar massive rock types (Unit MG) comprise what is probably the youngest unit in the Mudjatik Domain. Modal analyses of five representative thin sections are given in Table 15.

Biotite is found in all five slides in small amounts. The flakes are 0.1 to 2.5 mm long, generally fresh and show a random orientation. It is dichroic from pale straw yellow or pale brown to moderate brown or red-brown (0090, 0093). Haloes are numerous in sample 0090.

Quartz is invariably highly strained, but only in thin section 0094 has incipient granulation been noted. A weak dimensional orientation exists in two sections (0092, 0093). Most grains vary in size from 0.1 to 5.0 mm, although they can measure up to 8.0 mm. They enclose biotite and/or microcline, opaques, plagioclase and zircon. *Plagioclase* is oligoclase (An_{21-22}) and varies between 0.1 and 6.0 mm in diameter. Apatite and/or biotite, quartz and zircon occur as inclusions along with patches of exsolved microcline (0090, 0093, 0094). Plagioclase has locally suffered slight to moderate sericitization.

Table 15. Visually estimated modal compositions of Mudjatik Domain massive leucogranites and other compositionally similar massive rock types (Unit MG)[1]

Dept. No. (7708-)	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0089	Biotite quartz monzonite	3 ×	15 ∇	50(An_{22})	30 ∝*	Ap(1%), Ms, Op(1%), Zr(r)
0090	Biotite monzogranite	4 ×*	26 ∇	35(An_{21})∝ **	35 ∝	Chl, Op(r), Zr(ab)
0092	Leucosyenogranite	Tr ×	30 ∿ Δ	10(An_{21})	59 ∞ —	Ap(r), Op(1%), Sph(r), Zr
0093	Leucomonzogranite	Tr ×	33 ∿ Δ	32(An_{22})∝*	33 ∞ ∿*	Op(2%), Sph(r), Zr(ab)
0094	Leucomonzogranite	Tr ×	35 ∇	34(An_{21})∝ **	30 ∞*	Chl(r), Op(1%), Sph(r), Zr(r)

[1]See Appendix A for explanation of symbols used

Microcline shows well-developed cross-hatch twinning. It is usually microperthitic, with exsolved material generally occurring as fine string- or spindle-lamellae and rarely as blebs (0093) or patches (0094). Grains are typically 0.1 to 6.0 mm in diameter, but in places exceed 8.0 mm (0092). Microcline most commonly encloses biotite, plagioclase (albite-rimmed inclusions in 0090) and quartz, and more rarely apatite and zircon.

The main *accessory minerals* are opaques (normally 1 percent or more), zircon, muscovite, apatite and sphene. The opaques occur in trace amounts as anhedral granules spatially associated with biotite and zircon. These granules tend to be large (up to 2.0 mm across), equidimensional and isolated. They are mostly anhedral, enclosing quartz, sphene and zircon. Zircon is typically less than 0.3 mm long, anhedral to subhedral (0093), and very occasionally has multiple concentric overgrowths (0039, 0093). Apatite has been found in two of the five thin sections. In one sample (0089), it constitutes 1 percent of the rock and forms grains up to 1.3 mm in diameter. Muscovite occurs mainly as ragged terminations to biotite flakes. Sphene is widespread (0092, 0093, 0094) but rare, generally forming 0.1 mm diameter granules spatially associated with opaques.

Examination of all of the thin sections showed that these granitoid rocks have an inequigranular xenomorphic texture.

Virgin River Domain

General Geology

Felsic gneisses (Unit VF) form the dominant rock type in the portion of the Virgin River Domain which lies within this map area. Three subdivisions of the unit were recognized for mapping purposes. The first of these (Subunit VFa) contains about 5 percent biotite, as well as scattered microcline megacrysts which range from 1 to 3 cm in length. The rock is pink in colour, medium to coarse grained and poorly to well foliated. It has been identified in only three small regions, the largest situated along the western edge of the map area about 4 km east of the Nyberg Lakes. The second lies close to the Athabasca Group, 3 to 4 km east of Chymko Lake, and the third appears to form a short (3 to 4 km) narrow (less than 0.5 km) lens south of Billings Lake. Rocks of this subunit resemble the gneissose granites (possible Archean basement) of the Wollaston Domain (Units WGa, WGaa) and the homogeneous megacrystic felsic gneisses (Subunit MFa) of the Mudjatik Domain. The geological relationships of these gneisses to other felsic gneiss subunits of the Virgin River Domain and to supracrustal rocks are uncertain. The second subunit (VFb) is widespread and consists of pale pink, medium- to coarse-grained, poorly to moderately foliated quartzofeldspathic rocks. In many places, these rocks are closely associated with the third subunit (VFc), which is characterized by pale pink or grey medium-grained well-layered quartzofeldspathic gneisses containing amphibole-rich blocks up to 5 m across. This association is most clearly seen in two zones that parallel the structural trend. One of these lies adjacent to the Cable Bay Shear Zone and extends from Israison Lake in the southwest to Gaucher Lake in the northeast corner of the domain. The other zone lies adjacent to a discontinuous band of supracrustal rocks situated near the western edge of the map area.

Throughout this part of Virgin River Domain, the felsic gneisses are intimately associated with massive to locally poorly foliated, moderate to pale pink, medium- to coarse-grained *leucogranite* (Unit VG). Near Andres Lake in the northeast corner of the domain and south of Crockett Lake in the central part, the leucogranite forms small but mappable plugs. Elsewhere it usually constitutes 20 to 50 percent of the felsic gneisses; both gradational and cross-cutting contacts with the host gneisses were observed.

Two areas in the Virgin River Domain are underlain by supracrustal rocks of metasedimentary (Units VP, VSP, VQ and VI) and possibly metavolcanic (Unit VA) origin.

The more westerly of these extends from the vicinity of the Nyberg Lakes northwards to Westgate Lake, the supracrustals cropping out as six separate lenses. The southernmost lens is composed mainly of medium-grained, semipelitic to pelitic, sillimanite-garnet-biotite gneiss (graphitic in a few places) commonly injected by garnetiferous pegmatite. Along the northwestern side of this lens is a strip of amphibole gneiss interbanded with biotite-bearing felsic gneiss; the central part of the lens forms a tight basin occupied by banded iron formation. Magnetite-rich (greater than 40 percent Fe_2O_3) quartzitic bands, ranging from 1 cm to 1 m in thickness, are intercalated with garnetiferous quartzites, amphibolitic rocks and pelitic garnet-biotite gneisses. A second lens, situated to the west, consists of coarse-grained massive dark grey quartzite; to the east, a third narrow lens consists mainly of semipelitic biotite gneisses, with amphibole gneiss along its eastern edge. To the north, successive supracrustal lenses are composed of semipelitic biotite gneisses, pelitic to semipelitic sillimanite-garnet-biotite gneisses with a westerly edging of quartzite and, finally, banded amphibolite. The amphibilite grades westwards into fine- to medium-grained pelitic and semipelitic biotite

schists with intercalated banded amphibolite and pale pink fine-grained quartzofeldspathic schists and gneisses, most of which are of probable intrusive origin.

The eastern supracrustal zone crops out south of Cable Bay as a 15 km long wedge butting against the Cable Bay Shear Zone. Exposures are sparse, but the few found consist of metasediments that include highly weathered graphitic garnet-biotite schist in the north, in the area closest to the Athabasca sediments, and, in the south, fresh pelitic and semipelitic sillimanite-garnet-biotite schists interbanded with thin (1 to 3 cm) fine-grained dark grey quartzites.

Felsic Gneisses (Subunits VFa, b, c)

Estimated modes based on 21 representative samples of the Virgin River felsic gneisses are presented in Tables 16a, b and c. The following are the most significant features: (i) plagioclase is remarkably uniform in composition (mostly An_{21-23}); (ii) hornblende is exceptionally rare; (iii) biotite (especially in Subunit VFb) and plagioclase are almost always altered; and (iv) quartz is usually highly strained.

Biotite flakes vary from 0.1 to 2.0 mm in length and are dichroic from pale to moderate or dark brown. Although they generally show a preferred orientation, some flakes in all sections are randomly oriented; in one section (0105), a few are deformed by open warps and kinks. In Subunits VFa and VFb, biotite is usually chloritized, whereas, in Subunit VFc, it is only weakly altered. *Hornblende*, present in only trace amounts in Subunits VFa and VFb, is more widespread in rocks of Subunit VFc. Its pleochroic scheme varies considerably; in 0131, colours change from pale blue-green to pale grass green; in 0129 and 0136, from pale brown to moderate shades of grass green (with bluish tinges at grain margins in 0136); and, in 0166, from pale brown to moderate grass green and sea green. The grains are usually randomly oriented and reach a maximum length of about 2.0 mm. Hornblende is always xenoblastic, and encloses apatite and/or quartz and zircon.

Quartz shows undulose extinction. In many sections (0104, 0105, 0106, 0135, 0136, 0137, 0169, 0171, 0232), the largest grains (greater than 3.0 mm) are incipiently granulated. Minerals enclosed by quartz include apatite, biotite (showing parallel alignment in samples 0169, 0171), plagioclase, zircon and, rarely, a few microcline grains or acicular needles of sillimanite (or possibly apatite). *Plagioclase* is usually oligoclase with a composition in the range An_{21-23}. In places, albite forms partial rims around the oligoclase. Some post-crystalline plagioclase deformation is seen, especially as slightly bent twin lamellae in large grains. Maximum grain diameters generally lie between about 4.0 and 6.0 mm. Apatite and/or biotite, quartz and zircon, as well as patches of exsolved microcline, are the minerals most commonly enclosed within plagioclase. *Microcline*, abundant in felsic gneisses of Subunits VFa and VFb, is mostly microperthitic. In Subunit VFc, it forms sparsely distributed interstitial grains. In Subunits VFa and VFb, microcline is clearly cross-hatched; in only a few slides is tartan twinning poorly defined (0130, 0135, 0232, 0233) or absent (0131). Microcline commonly encloses biotite and/or plagioclase, quartz and, rarely, apatite, garnet and zircon. Maximum grain size is about 6.0 mm, although most grains are about 3.0 mm. In contrast to these features, all microcline in rocks of Subunit VFc is weakly cross-hatched, fine grained (normally less than 0.5 mm) and, apart from a few relatively coarse grains which enclose plagioclase and quartz, lacks inclusions. Microperthitic exsolution in microcline of Subunits VFa and VFb varies from abundant string- and spindle-lamellae in most grains (samples 0130, 0158, 0171, 0172) to sparse spindle-lamellae in a few of the largest grains (samples 0104, 0169) to complete absence (samples 0103, 0106, 0232, 0233).

Accessory minerals in virtually all of the Virgin River Domain felsic gneisses are apatite, opaques and zircon. Apatite generally forms subidioblastic to xenoblastic grains, rarely longer than 0.4 mm. Opaques, less abundant than in felsic gneisses of the Mudjatic Domain, occur in veins (0158), as dust or tiny granules (less than 0.2 mm across) associated

Table 16a. Visually estimated modal compositions of Virgin River Domain felsic gneisses (Subunit VFa)[1]

Dept. No. (7708-)	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0158	Quartz monzonitic biotite gneiss	5 ∿ x***	15	40(An_{21}) ∝***	40 ∞	Ap(r), Chl, Op(r), Zr(ab)
0164	Monzogranitic biotite gneiss	5 ∿ x*	30 ∇	40(An_{21}) ∝*	25 ∝	Ap, Chl, Op, Zr
0171	Monzogranitic biotite gneiss	5 — x	25 ∿ ∇	30(An_{23}) ∝**	40 ∞	Ap, Op, Zr, Sill (?, r in Qz, Pl)

[1]See Appendix I for explanation of symbols used

Table 16b. Visually estimated modal compositions of Virgin River Domain felsic gneisses (Subunit VFb)[1]

Dept. No. (7708-)	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0103	Monzogranitic biotite gneiss	7 ∿ ×***	20 ∿	43(An_{21})**	30	Ap, Chl, Op, Zr
0104	Monzogranitic biotite gneiss	5 ×**	30 ∇	35(An_{21}) ∝**	30 ∝	Ap, Chl, Op(r), Ru(?), Zr(r)
0106	Monzogranitic biotite gneiss	5 ×**	30 ∇	40(An_{21}) ∝**	25	Ap, Chl, Op, Zr
0130	Granodioritic biotite gneiss	8 — ×**	20 Δ	55(An_{22}) ∝*	16 ∞	Ap, Chl, Op(1%), Zr
0131	Granodioritic biotite gneiss	5 ∿**	35 Δ	45(An_{23}) ∝**	15 ∝	Ap, Hb, Op(r), Zr
0135	Monzogranitic biotite gneiss	6 — ×	35 ∇	35(An_{23})*	23 ∝	Ap(ab), Op(1%), Zr
0137	Monzogranitic biotite gneiss	5 — ×*	30 ∿ Δ	25(An_{23}) ∝**	40 ∝	Ap, Chl, Op, Zr
0169	Granodioritic biotite gneiss	5 ∿ ×**	30 ∿ ∇	50(An_{21})**	15 ∝	Ap, Chl, Op(r), Zr(r)
0172	Monzogranitic biotite gneiss	5 ∿ ×**	32	35(An_{18}) ∝**	25 ∞*	Gt(3%, o**), Ms, Op(r), Zr(r)
0232	Granodioritic biotite gneiss	5 ×*	30 ∇	50(An_{21})∇ ∝***	15	Ap, Chl, Ms(r), Op, Ru (r), Zr
0233	Granodioritic biotite gneiss	8 — ×**	30 — ∇	45(An_{21})∇ ***	17 ∿	Ap, Chl, Zo(?), Zr

[1]See Appendix A for explanation of symbols used

with biotite alteration or, most often, as xenoblastic (or rarely subidioblastic) equidimensional grains up to 1.0 mm in length. Zircon normally forms xenoblastic, rounded crystals less than 0.2 mm long. In some slides, two varieties of zircon appear to be present: a small clear type less than 0.2 mm in size and a larger pale brown type 0.1 to 0.4 mm in size. Possible sillimanite (or apatite) needles are enclosed in plagioclase and quartz in 0171. Also, subidioblastic to xenoblastic garnet crystals, 0.3 to 5.0 mm across and full of randomly oriented biotite and quartz, are abundant in 0172. The felsic rocks in the Virgin River Domain are more extensively altered than elsewhere in the map area. The main *alteration products* are chlorite and sericite.

Inequigranular and equigranular interlobate textures are commonly developed, and polygonization is rare. Cataclastic textures, mainly affecting quartz grains, are seen in sample 0136; these textures include ribboning and granulation of quartz, as well as suturing of interquartz boundaries.

Table 16c. Visually estimated modal compositions of Virgin River Domain felsic gneisses (Subunit VFc)[1]

Dept. No. (7708-)	Rock Name	Biotite	Horn-blende	Quartz	Plagioclase	Microcline	Accessory Minerals
0098	Tonalitic biotite gneiss	15 — ×		29 — ∇	60(An_{23}) ∝	1*	Ap(ab), Op(r), Zr(r)
0105	Trondhjemitic biotite gneiss	6 ∿ × Λ*		35 ∇	55(An_{21}) ∝**	3	Ap(ab), Op(1%), Sph (ab), Zr
0128	Tonalitic biotite gneiss	10 — ×		27 Δ	60(An_{23}) ∝**	3	Ap, Op(r), Zr
0129	Tonalitic hornblende-biotite gneiss	8 — ×	3*	20 Δ	68(An_{23}) ∝	Tr	Ap(ab), Op(1%), Zr
0136	Trondhjemitic hornblende-biotite gneiss	5 — ×	2*	32 — ∇	60(An_{25})*	1	Ap, Op, Zr
0163	Tonalitic biotite gneiss	10 — ×*		30 ∇	60(An_{21})*	Tr	Ap, Chl, Op(r), Zr
0166	Tonalitic biotite-hornblende gneiss	10 — ×	10 —	25 — ∇	55(An_{44})*		Ap, Op(r), Zr

[1]See Appendix A for explanation of symbols used

Table 16d. Visually estimated modal composition of 'regolith' boulder, probably derived from Virgin River Domain granitoid rock[1]

Dept. No. (7708-)	Rock Name	Quartz	Plagioclase	Microcline	Accessory Minerals
0109	'Regolith' derived from granitoid rock	35 ∿ ∇	60****		Ep(r), Op(4% ∿), Se as flakes (1%), Zr(r)

[1]See Appendix A for explanation of symbols used

Thin-section examination of a **regolith** sample, probably derived from Virgin River Domain felsic gneiss (Table 16d), showed that little of the rock's primary mineralogy has been preserved. *Quartz* is strained to an extreme degree, and some grains are incipiently granulated and show weak preferred dimensional orientation. *Feldspar* is totally altered to very fine grained (less than 0.05 mm) sericite; the sericite fills cracks in many of the quartz grains. A reddish brown opaque material (about 4 percent) occurs as very fine granules concentrated into irregular wisps with a weak alignment which defines a poor planar fabric.

Amphibole-Rich Schists and Gneisses (Unit VA)

A total of six representative samples of the Virgin River Domain mafic gneisses (Unit VA) have been microscopically studied (Table 17). Of these, all but one (0162) are from areas underlain by probable supracrustal rocks. Felsic gneisses of Subunit VFc host the amphibolite block from which sample 0162 was collected. Slides of two samples of probable supracrustal origin (0100, 0138) show delicately layered, alternating hornblendic and quartzofeldspathic laminae.

The *felsic layers* contain about 5 percent mafic minerals; the dominant mafic mineral is a pale straw yellow or pale brown to moderate or dark brown biotite. The biotite flakes are less than 0.5 mm long and show a random (0100) to well-oriented (0138) fabric. Trace amounts of amphibole are present, as well as apatite, opaques, zircon and sphene (only in 0138). Quartz (very weakly strained) and plagioclase (andesine, An_{30-34}) are abundant; microcline is also present in small amounts. Their grain size rarely exceeds 0.2 mm.

The *mafic layers* are composed almost entirely of biotite and hornblende in sample 0100; in addition, quartz and plagioclase are present in sample 0138 at the expense of biotite. Biotite flakes reach 2.0 mm in length and are generally well oriented. Hornblende crystals, pleochroic in pale to moderate shades of brown, grass green and bluish green, attain lengths of 5.0 mm, are locally well oriented (0138) and enclose apatite and/or biotite, plagioclase, quartz and sphene. Epidote (formed mainly around opaque grains), opaques and zircon also occur in the mafic layers.

The texture of these layered mafic gneisses is equigranular (in any one layer) polygonal granoblastic. A second, very weak schistosity, defined by biotite oriented at a high angle to the main schistosity (which is parallel to compositional

Table 17. Visually estimated modal compositions of Virgin River Domain amphibole-rich schists and gneisses (Unit VA) from different geological settings[1]

Dept. No. (7708-)	Rock Name	Biotite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
0100	Hornblende-biotite schist layers	72 — ×	28**				Ap, Ep(ab), Op, Sph (ab), Zr(?)
	Quartzofeldspathic layers	5 ×	Tr	35	60(An_{34}) ∝*	Up to 5	Ap(r), Op(r), Zr(r)
0101	Epidote-chlorite schist			25 ∿ Δ	20(An_{12})		Ap(r), Chl(35% — ×), Ep(20%**), Op
0102	Quartz-rich biotite-hornblende gneiss	2 ×	35 ∿**	30 Δ			Ap(ab), Ms or Se (30% ∿ ×), Op(3%)
0138	Hornblende gneiss layers	5	45	5	44(An_{35})*		Ap, Chl, Op(r), Sph(1%), Zr
	Quartzofeldspathic layers	5 — ×*	1 —	30	59(An_{30}) ∝	4	
0160	Biotite amphibolite	5 — ×**	50 —	2	42(An_{36})***		Ap, Chl, Op(1%), Zr(r)
0162	Biotite amphibolite	10 ∿	35	2	50(An_{42})***		Ap(ab), Cbt, Op(3%), Sph, Zr(r)

[1]See Appendix A for explanation of symbols used

layering), possibly exists in sample 0100. It is perhaps related to tight folds deforming the layering.

Two of the remaining three mafic gneisses of probable supracrustal origin (0101, 0102), collected near the Dufferin Lake Fault, are strongly retrogressed and contain considerable highly strained *quartz* in the form of lensoid segregations and veins. *Biotite* occurs in sample 0102 as minute, pale straw yellow to moderate brown flakes which appear to be spatially and genetically associated with late cross-cutting quartz veins. *Hornblende*, also present in sample 0102, forms weakly oriented crystals, 0.02 to 1.0 mm in length, which are pleochroic in pale shades of brown, grass green and blue-green, and which enclose quartz grains. It shows moderate marginal alteration to biotite. *Plagioclase*, recognizable only in sample 0101, occurs mainly as small cloudy grains. Although difficult to determine, the composition appears to be approimately An_{12}. Weakly oriented sericite and/or muscovite flakes up to 0.5 mm long in sample 0102 may have been derived from plagioclase. Chlorite, serpentine and a finely granular epidote mineral, probably clinozoisite, are abundant in sample 0101 and are possibly the *alteration products* of amphibole. Apatite and opaques are *accessory minerals*.

Sample 0160 seems to be the only mafic specimen that has largely escaped the effects of retrograde metamorphism. *Biotite*, pale to moderate brown in colour, clearly defines a planar fabric, although some flakes are transversely oriented. It is extensively chloritized in places. *Hornblende* is pleochroic in pale shades of brown and moderate shades of greenish brown. Well-oriented xenoblastic prisms define the main schistosity along with biotite. Poikiloblastic crystals, about 2.0 mm long, enclose apatite and/or opaques, plagioclase, quartz and zircon. *Quartz* shows little sign of strain and occurs as small interstitial or enclosed grains. *Plagioclase* (An_{36}) is extensively sericitized and locally saussuritized. *Accessory minerals* include apatite (stubby 0.2 mm diameter idioblasts), opaques (subidioblastic equidimimensional grains up to 0.3 mm) and zircon (rare rounded crystals). The rock has an equigranular polygonal nematoblastic texture.

The amphibolite block (0162) which occurs within the felsic gneisses of Unit VFc lacks the well-defined schistosity apparent in most of the supracrustal-type mafic gneisses. *Biotite* flakes, up to 2.5 mm long, show a very crude preferred orientation. *Hornblende* grains, up to 4.0 mm in size, are pleochroic from pale brown to moderate shades of grass green and blue-green, and enclose apatite and/or opaques, plagioclase and quartz. *Quartz* grains are moderately strained, range up to 3.0 mm in size and enclose apatite and hornblende. Extensively saussuritized *plagioclase* (An_{42}), mostly about 1.0 mm in size, encloses apatite and/or hornblende, opaques and zircon. The main *accessory minerals* are apatite (subidioblastic to idioblastic and up to 0.4 mm long), opaques (subidioblastic to xenoblastic, generally equidimensional and up to 1.5 mm across) and zircon (tiny rounded crystals). Some of the opaque grains are coated by carbonate and sphene. The rocks typically show an equigranular interlobate to polygonal granoblastic texture.

Metasediments (Units VP, VSP, VPS, VQ, VI)

Pelites (Unit VP, Table 18a) and semipelites (Unit VSP, Table 18b) are volumetrically the most important metasedimentary rock types in the Virgin River Domain. Psammites (Unit VPS, Table 18c) with

Table 18a. Visually estimated modal compositions of Virgin River Domain pelitic schists and gneisses (Unit VP)[1]

Dept. No. (7708-)	Rock Name	Biotite	Garnet	Sillimanite	Chlorite	Quartz	Plagioclase	Microcline	Accessory Minerals
0107	Pelitic biotite-chlorite schist	15 – × Λ	?Tr****	?Tr(in Qz)	25 ∿ ×	55 ∿ ∇			Ap, Ms(1%), Op(4%), To, Zr(r)
0108	Pelitic chlorite-biotite schist	25 ∿ ×		?Tr(in Qz)	20 ×	45 ∿ ∇			Ap(ab), Ms(r), Op (5%)
0134	Pelitic chlorite-biotite schist	25 – ×		?Tr(in Qz)	15 ∿ ×	50 ∿		10**	Gr(?), Hb*, Ms, Op, Zr
0140	Pelitic hornblende-biotite schist	53 – ×				15	25(An_{60})*		Ap, Hb(7%), Op, Zr(?)
0141[2]	Pelitic muscovite-biotite gneiss	20 – ×		?Tr(in Qz)****	Tr	50 ∿	25(An_{15})		Ap(r), Ms(5%), Op, To, Zr
0167	Pelitic sillimanite-garnet-biotite gneiss	15 ×***	7 ○	4(esp. in Qz, Bt)***	25	35		14****	Op, Sph, Zr
0235	Pelitic garnet-sillimanite-biotite schist	20 – ×*	2 ∿	6**** (fresh in Qz)	Tr	35 – ∇	35***		Ap, Gr(?), Ms(2% ×), Op, To(r), Zr
0236	Pelitic muscovite-sillimanite-biotite schist	15 – Λ**		10**∿ (in Qz)	Tr	50 – ∇	15(An_{20})***		Ap, Gr(?), Ms(7%), Op(3%), Zr

[1]See Appendix A for explanation of symbols used

[2]Collected from about 0.25 km west of map area

Table 18b. Visually estimated modal compositions of Virgin River Domain semipelitic gneisses (Unit VSP)[1]

Dept. No. (7708-)	Rock Name	Biotite	Garnet	Sillimanite	Chlorite	Quartz	Plagioclase	Microcline	Accessory Minerals
0121	Semipelitic biotite gneiss	19 — ×	Tr o			40 — ∇	40(An_{25})*		Ap(r), Hb(?), Ms(1%), Op(ab), Zr(ab)
0122	Semipelitic biotite gneiss	15 — ×				64 — ∇	20(An_{38})**		Ap, Op(1%), Zr
0132	Semipelitic garnet-chlorite-biotite gneiss	15 — ×***	2**	Tr*** (fresh in Qz)	8 ×	77 ∿ ∇	Tr ****		Ap(ab), Gr(?), Hb, Op Zr
0159	Semipelitic garnet-biotite gneiss	10 ×***	5***		Tr	20 ∇	35(An_{35})***	30 ∝	Ap(r), Cbt, Op(ab), To(r), Ru(?), Zo, Zr
0173	Semipelitic garnet-biotite gneiss	19 — ×	1 o			35	30(An_{33})*	15	Ap(r), Gr(?), Op, Serp, Zr(ab)
0234	Semipelitic sillimanite-biotite gneiss	20 — A		3**** (fresh in Qz)	Tr	40 ∿ ∇	37***		Ap, Gr(?), Ms, Op, Zr

[1]See Appendix A for explanation of symbols used

abundant feldspar (meta-arkoses) have not been recognized in this map area but may be represented by some of the felsic gneisses. Quartzites (Unit VQ, Table 18d) are abundant and banded iron formation (Unit VI, Table 18e) is locally plentiful.

Biotite in the pelites and semipelites has a grain size ranging from 0.05 to 2.0 mm and is most commonly pale to moderate or dark brown in colour, locally with greenish tinges (0108). Elsewhere, flakes are dichroic from pale brown or straw yellow to pale brown (0235, 0236), moderate reddish brown (0132, 0134, 0167) or moderate orange-brown (0141, 0173, 0234). Haloes are generally more abundant (0132, 0134, 0141, 0167, 0235) than in biotite of any other rock units in the map area. Two generations of biotite appear to be present in several thin sections (0107, 0108), with late flakes cutting across early ones. In samples collected from areas near the Cable Bay Shear Zone (0107, 0234, 0235, 0236), the biotite flakes are bent, kinked and stained. They rarely enclose other minerals, except for minute grains of zircon. Biotite is xenoblastic, and is chloritized in about 35 percent of the samples from Units VP and VSP. In Units VPS, VQ and VI, biotite is relatively sparse and is invariably chloritized to at least a slight degree. It is dichroic from pale to moderate or dark brown. Haloes are rare, as are inclusions of other minerals. Flakes range in length from less than 0.05 to 1.5 mm.

Garnet is present in all of the metasedimentary map units. It generally forms subidioblastic to xenoblastic grains, up to about 7 mm in diameter, which are full of inclusions of biotite and/or quartz and/or (rarely) apatite or opaques. These inclusions nowhere define an internal planar fabric within garnet. In sample 0167, they are concentrated towards the cores of the largest garnets, leaving rims inclusion-free. Garnet is commonly altered to chlorite, biotite and/or opaques. Zoisite occurs at grain margins and along internal cracks.

Sillimanite is common in pelitic schists and gneisses of Unit VP, usually in only trace amounts as acicular needles preserved in quartz. It also occurs sporadically in semipelites (Unit VSP) and quartzites (Unit VQ). Where not enclosed in quartz, it is extensively to completely altered to finely crystalline micaceous shimmer aggregates, or is pseudomorphed by chlorite (0132, 0234). Sillimanite is best developed and least altered in sample 0167, where it occurs in the groundmass as both discrete prisms up to 0.2 mm in diameter and as fibrolite, and in specimens 0235 and 0236, where it forms lenses of brownish fibrolite (individual fibres 0.02 to 0.03 mm in diameter) marginally converted to muscovite and chlorite.

Amphibole is present in a few thin sections (0121, 0134, 0140, 0165, 0168). It is pleochroic from pale brown to pale grass green (0140), moderate grass green (0134), moderate grass green and blue-green (0165), moderate greenish blue (0121) and colourless (grunerite, sample 0168). Polysynthetically twinned grunerite poikiloblasts, ranging from less than 0.1 up to 2.0 mm in size, enclose biotite, garnet, quartz and zircon

Table 18c. Visually estimated modal composition of Virgin River Domain psammitic gneiss (Unit VPS)[1]

Dept. No. (7708-)	Rock Name	Biotite	Garnet	Quartz	Plagioclase	Microcline	Accessory Minerals
0142[2]	Psammitic biotite gneiss	8 — ×**	?Tr***	30	45(An_{18})	17	Ap, Chl, Op, Zr(r)

[1]See Appendix A for explanation of symbols used

[2]Collected from about 0.4 km west of map area

Table 18d. Visually estimated modal composition of Virgin River Domain quartzite (Unit VQ)[1]

Dept. No. (7708-)	Rock Name	Biotite	Garnet	Sillimanite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
0133	Biotite-garnet quartzite	3***	5*	Tr(around Gt, in Qz)		92 ∇	Tr	Tr	Ap, Chl, Cr(?), Ms, Op, Zr(r)
0165	Hornblende quartzite	Tr***			7 — **	92 ∿ ∇	Tr***		Ap, Cbt, Chl(1%), Ep, Op, Zr(r)

[1]See Appendix A for explanation of symbols used

(surrounded by pleochroic haloes), and are interstitial to garnet. They are moderately altered to an orange amorphous mineraloid and opaques. Elsewhere, the amphibole is hornblendic, is of similar grain size to the grunerite, and encloses quartz and plagioclase. In sample 0165, oriented amphibole helps define a planar fabric but in general is randomly oriented. Marginal alteration to chlorite and biotite with subordinate opaques (0140), epidote and/or carbonate (0165) is characteristic.

Chlorite is widespread in minor amounts as an alteration product of mafic minerals. In several samples (0107, 0108, 0132, 0134), it is an essential rock-forming mineral and co-exists with late-stage biotite and muscovite (0107, 0108). It also occurs as flakes that cut across either the schistosity defined by early biotite (0134) or the individual grains of the early biotite (0132). Chlorite also infills widespread branching veinlets up to about 0.2 mm wide, which are best developed where they transect quartz grains (0107, 0108, 0132, 0167, 0235). In other places, chlorite forms radiating aggregates (0108) or pseudomorphs after sillimanite (0132, 0234) and plagioclase (0167, 0234, 0235, 0236). Chloritization is most intense in those metasediments that lie near the Cable Bay Shear Zone.

Quartz, generally abundant, commonly shows a preferred dimensional orientation and extreme undulose extinction, particularly in the metasediment samples (0107, 0108, 0121, 0122, 0234, 0235, 0236) collected near the Cable Bay Shear Zone. In these, the quartz grains are commonly ribboned and the interquartz boundaries sutured. In sample 0236, quartz shows weak axial planar reorientation in the hinge zones of small-scale open folds. Incipient granulation has been observed in two sections (0132, 0133). Quartz grains in four sections (0107, 0108, 0132, 0167) have been extensively fractured and infilled with chlorite. Quartz encloses biotite, sillimanite and zircon, as well as apatite, feldspar, garnet, aligned hornblende (in 0165 giving an internal schistosity) and opaques. The grain size is variable, the maximum observed diameter in the quartzites being 22.0 mm (0165). More typically, however, the quartz grains vary from less than 0.1 to about 2.0 mm in size.

Plagioclase is often so extensively altered (0132, 0167) that there can be difficulty in distinguishing it from microcline. In the few cases where its composition can be measured, it varies from oligoclase (An_{15}) to labradorite (An_{60}), with most of the specimens lying in the range An_{20-40}. The grain size varies from less than 0.1 to about 1.5 mm.

Microcline rarely occurs in more than trace amounts but, where it does, microperthitic exsolution is common in the form of string- or spindle-lamellae or patches. The microcline crystals rarely exceed 10.0 mm in size.

Apatite, muscovite, opaques and zircon are the most widespread *accessory minerals*. Apatite is typically xenoblastic, more rarely subidioblastic or idioblastic (0108, 0165), and ranges up to 0.3 mm in size. Muscovite, particularly abundant in the pelites, constitutes up to 7 percent (0236) of the rock, and forms flakes up to 2.0 mm long which are oriented obliquely to the main schistosity. These flakes are interleaved with, or cut sharply across, biotite flakes. They are deformed in several thin sections (0107, 0235, 0236) and enclose sillimanite (0141, 0236) and/or biotite, opaque grains and zircon. Muscovite is poorly developed in the other metasedimentary units. Opaque minerals include finely granular material (less than 0.05 mm across) spatially associated with biotite (0107, 0132, 0142); xenoblastic to idioblastic, locally skeletal (0167), equidimensional grains up to about 1.0 mm across; slightly translucent, yellowish or reddish brown

Table 18e. Visually estimated modal composition of Virgin River Domain garnet-rich rock present within banded iron formation (Unit VI)[1]

Dept. No. (7708-)	Rock Name	Biotite	Garnet	Grunerite	Quartz	Accessory Minerals
0168	Weakly foliated biotite-grunerite-quartz-garnet rock	7 ∿ x*	48 o*	15 o**	30 ∇	Ap(ab), Chl, Op(ab), Zr

[1]See Appendix A for explanation of symbols used

Table 18f. Visually estimated modal composition of concordant foliated granite layer in pelitic and semipelitic biotite schists of the Virgin River Domain (Units VP, VSP)[1]

Dept. No. (7708-)	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0139	Biotite alkali-feldspar granite	5 — x****	25 — ∇	35(An_6)***	35	Ap, Chl, Ms(× ab), Op, Zr

[1]See Appendix A for explanation of symbols used

material (probably hydrated iron oxide, 0108, 0234); and flaky grains of possible graphite (0107, 0132, 0173, 0234, 0235, 0236) often enclosed within biotite. Zircon occurs mainly as tiny (up to 0.1 mm diameter) rounded grains, some showing concentric overgrowths (0107, 0236). Tourmaline is patchily developed, generally as idioblastic prisms (0107, 0141, 0159, 0235). Sphene forms granular patches in specimen 0167.

Apart from chlorite and sericite, *alteration products* include carbonate, epidote, rutile, serpentine and zoisite.

The most intensely developed cataclastic texture predates crystallization of late chlorite, biotite and muscovite crystals, and is found in all metasediments collected adjacent to the Cable Bay Shear Zone. An inequigranular interlobate granoblastic texture is dominant in the pelites (0134, 0167), whereas an equigranular interlobate texture is common in the semipelites (0132, 0159, 0173). Elsewhere, equigranular polygonal granoblastic textures (0140, 0141, 0142, 0168) are developed.

Concordant bands of pale pink, medium-grained, schistose granite are locally abundant in the lenses of supracrustal rock, especially in the northwestern corner of the map area. They are represented by a single thin section (0132) whose mode is presented in Table 18f.

Biotite grains, 0.1 to 1.0 mm long, are normally well aligned and are almost completely chloritized. Where fresh, they are dichroic in pale to moderate shades of brown.

Quartz is highly strained and shows an excellent preferred dimensional orientation. The longest grains reach 4.5 mm in length and have a width of about 0.7 mm. They enclose biotite, microcline, plagioclase and zircon. Extensively sericitized *plagioclase* (albite, An_6) varies from 0.1 to 2.0 mm across and encloses biotite, quartz and zircon. *Microcline*, lacking microperthitic exsolution, ranges in size from 0.1 to 2.0 mm.

Accessory minerals include idioblastic to xenoblastic apatite (up to 0.1 mm in diameter), abundant randomly oriented muscovite flakes (up to 0.2 mm long), opaque granules (usually less than 0.05 mm) and zircon.

The alkali-feldspar granite has a predominantly inequigranular interlobate granoblastic texture accompanied by localized polygonization or, elsewhere, by incipient cataclasis.

Leucogranite (Unit VG)

The massive leucogranite (Unit VG), examined in only two thin sections (Table 19), is monzogranitic in composition.

Randomly oriented *biotite* flakes vary from 0.1 to 2.0 mm in length and are dichroic from pale to moderately dark brown. Haloes are rare.

Quartz is very highly strained and shows incipient granulation. The grains range from 0.1 to 7.0 mm in size and enclose apatite and/or biotite, microcline and zircon. *Plagioclase* (An_{21-24}) has bent and strained multiple twin lamellae in sample 0161 and very thin albitic rims in sample 0170. Crystals range from 0.1 to 6.0 mm across and commonly contain biotite, quartz, and patches of exsolved microcline. *Microcline*, is also coarse grained (up to 7.0 mm across), and is commonly microperthitic, with

Table 19. Visually estimated modal compositions of Virgin River Domain massive granitic rocks (Unit VG)[1]

Dept. No. (7708-)	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0161	Biotite monzogranite	5 ×	25 ∇	40(An_{24}) ∝	30 ∝	Ap, Op, Zr(r)
0170	Biotite leucomonzogranite	3 x*	35 ∇	30(An_{21}) ∝**	32 ∞	Ap, Chl, Op, Zr

[1]See Appendix A for explanation of symbols used

exsolved plagioclase typically forming string- or spindle-lamellae, blebs or flame-shaped wedges. It encloses biotite, quartz and zircon.

Accessory minerals include apatite, opaques and zircon. Xenoblastic apatite ranges up to 0.7 mm in size. Opaques form subidioblastic to very irregularly shaped grains up to 2.0 mm in diameter. Zircon crystals are rounded to subidioblastic and up to 0.3 mm in diameter. *Alteration products* include sericite and chlorite.

Inequigranular xenomorphic textures are developed.

Athabasca Group (Unit AG)

Because of the scarcity of exposures along the south-central edge of the Athabasca Basin, few samples of the Athabasca Group (Unit AG) were examined in detail. Ramaekers (1977) has already summarized the geology of this part of the Athabasca Group and little information can be added from the present survey. Particular attention, however, was paid to boulders of the Athabasca Group, especially those with conglomeratic textures. In the conglomerates, all of the observed clasts were of pure quartz (fine to very coarse grained; dark smoky grey to milky white). The largest clasts (maximum diameter of 17.0 cm) were found 2 km southwest of Wheeler Lake in boulders measuring about 1 m in diameter and composed of ill-sorted, poorly supported, monomictic conglomerate. Elsewhere, clasts rarely exceeded 8.0 cm in size.

Table 20 gives the modal composition of a single sample of Athabasca Group conglomerate (0113) collected from the northeastern end of a 6 km long train of radiometrically anomalous conglomerate boulders situated southeast of Blanchard Lake. The rock is rusty brown in colour and contains numerous quartz clasts up to 1 cm across, some of which are dark smoky grey and transparent.

In thin section, *quartz* constitutes about two-thirds of the specimen and takes the form of subrounded to angular grains less than 0.25 mm across. Occasionally, it occurs as rounded to subangular grains greater than 0.25 mm across. It is always highly strained and, in places, encloses zircon. The remaining third of the sample consists of discrete well-rounded grains of opaque material (possibly hematite) and an interstitial cement of finely granular, slightly translucent, dusty-looking, grey-green material (possibly siderite). Two other minerals each form about 1 percent of the conglomerate. One is a platy mineral, probably a chlorite, which is pleochroic in neutral, pale straw yellow and pale yellowish brown colours, and which shows an anomalous grey birefringence. The other mineral is subidioblastic to rounded zircon in grains up to 1.25 mm across; some have multiple overgrowths. Several small areas of the thin section consist of a colourless mineral with a moderate relief and first order grey birefringence; its refractive index is less than that of quartz. Possibly chlorite, this mineral occurs as weakly developed, radiating aggregates.

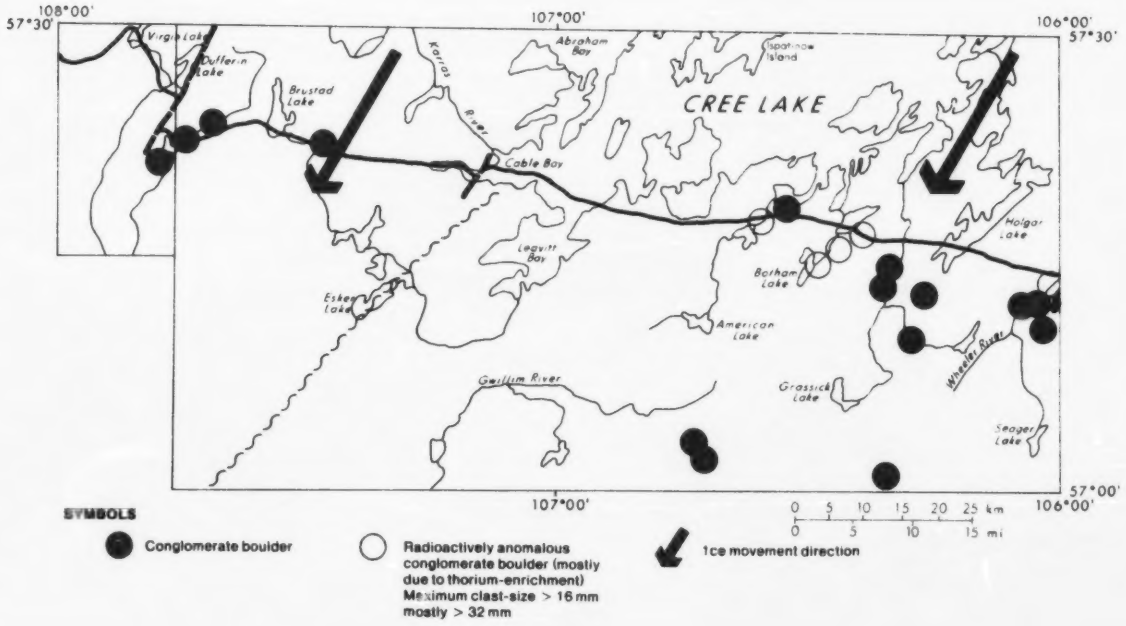

Figure 8. *Distribution pattern of Athabasca Group conglomerate boulders*

Table 20. Visually estimated modal composition of boulder of pebbly conglomerate, probably derived from the base of the Athabasca Group (Unit AG)[1]

Dept. No. (7708-)	Rock Name	Haematite+Siderite(?)	Quartz	Accessory Minerals
0113	Pebbly conglomerate	33	65 Δ	Chl or pale Bte(1%), Mz or Zr(1%)

[1]See Appendix A for explanation of symbols used

Diabase Dykes (Unit G)

Although diabase dykes (Unit G) were observed in outcrop in only two places in the pre-Helikian crystalline basement, gabbroid boulders are scattered throughout the map area. These virtually unmetamorphosed basic intrusive rocks are more often found cutting the Athabasca Group (e.g. at Diabase Peninsula on the west shore of Cree Lake). An age of 1230 Ma has been obtained by Burwash et al. (1962) on a diabase sample from this locality. Diabase outcrops and boulders appear to lie within, or originate from, a 6 km wide zone (the Cree Lake Dyke Swarm) that trends northeastwards from Seager Lake (Figure 3). The diabase is coarse gained, friable, dark green, magnetic and generally has a subophitic texture. The modal compositions of two diabase samples are given in Table 21.

Biotite (up to several percent) is present as randomly oriented, evenly distributed flakes which are dichroic from pale to moderate brown and which commonly surround opaques or amphibole. Flakes range up to about 0.4 mm in diameter, are hexagonal in basal sections, and have an almost colourless rim. Biotite is evidently late relative to the crystallization of most other component minerals. *Amphibole* (hornblende) forms ragged anhedral crystals up to about 4 mm long which are either complexly intergrown with, or form a rim around, pyroxene. Amphibole is also graphically intergrown with plagioclase. It is pleochroic in pale and moderate shades of brown, grass green and blue-green. Naturally coloured *clinopyroxene*, probably augite, is anhedral and highly altered, especially at margins with hornblende. Some grains appear to be schillerized (sample 0110).

Interstitial *quartz*, up to 1.5 mm across, locally encloses apatite and, in one sample (0110), is granophyrically intergrown with plagioclase. *Plagioclase* (labradorite, An_{62-68}) occurs as long (up to 8.0 mm), narrow, randomly oriented blades which enclose apatite.

Apatite, an abnormally abundant *accessory mineral*, occurs as long (up to about 1.5 mm), thin (about 0.05 mm), randomly oriented euhedral needles, many with cloudy cores. Opaques, which are also abundant, occur as equidimensional or blade-like subhedral skeletal grains and as aggregates. Up to about 2.0 mm in diameter, they commonly are rimmed by biotite. Zircon and epidote are also present but rare. Amphibole and pyroxene are altered to a yellow-brown or red-brown, non-pleochroic amorphous material which locally shows a subspherical radiating texture. Plagioclase is moderately sericitized.

Primary igneous textures are well displayed in the diabase. Plagioclase laths, for example, are subophitically enclosed by augite (or hornblende), and quartz and plagioclase show granophyric textures. Late-stage hydrothermal effects were probably responsible for the sericitization of plagioclase and for the alteration of augite to hornblende and to biotite.

Table 21. Visually estimated modal compositions of massive quartz diabase dykes of Helikian age injected into pre-Athabasca Group basement[1]

Dept. No. (7708-)	Rock Name	Biotite	Amphibole	Pyroxene	Quartz	Plagioclase	Accessory Minerals
0110	Quartz diabase	2 ×	24**	10**	5	55(An_{62})**	Ap(2%), Op(2%), Serp(r), Zr(r)
0114	Quartz diabase	4 ×	20**	15**	5	55(An_{68})**	Ap(1%), Ep(r), Op(1%), Serp(r)

[1]See Appendix A for explanation of symbols used

Structure and Metamorphism

All pre-Helikian rocks in the map area (other than late massive granitoid intrusives) show the effects of polyphase deformation and metamorphism. The earliest recognizable fabric is a regionally developed schistosity and/or gneissosity (S_1). Bedding and primary depositional structures are not preserved. Variations in the paleosome of the supracrustals and, to a lesser extent, of the felsic gneisses reflect possible primary compositional differences in the regional sediments and/or volcanics. Such variations are concordant with S_1.

A map of the early foliation trends (Figure 9) and the arcuate outcrop pattern characteristic of the supracrustal rocks (Figure 3) indicate the existence of large dome-and-basin structures, mostly elongated in a north-northeasterly direction. The overall structural grain is similar to that described from south of the map area (Lewry and Sibbald, 1977, 1980; Munday, 1977; Pearson, 1977; Pearson and Lewry, 1974).

Not only are there lithological differences in the rocks of the three domains in the area, but thermotectonic differences are also evident. The small part of the area thought to lie within the Wollaston Domain shows an apparent structural simplicity and an absence of major stratigraphic repetition. These features, as well as the upper amphibolite facies metamorphism with little accompanying migmatization, appear to be typical of this domain (Lewry and Sibbald, 1980). In the west, the Virgin River Domain thermotectonically resembles the Wollaston Domain, but has suffered more severe retrogression.

In the Mudjatik Domain, the interference structures are more open, lacking the linearity shown in the neighbouring domains. Regionally developed, hypersthene-bearing mineral parageneses, indicative of a widespread granulite facies metamorphic peak, are more common than in the Wollaston Domain (Money, 1966; Ray, 1974, 1975; Fuh, 1976; Lewry, 1977). They are abundant in the felsic gneisses and almost ubiquitous in the mafic gneisses (Figure 10). Both during and following this metamorphism, extensive migmatization, particularly of the metasediments, took place throughout the domain. Such high metamorphic grades do not seem to have been reached in the Virgin River Domain, where hypersthene occurrences have yet to be recorded.

First Thermotectonic Event (D_1)

An early, regionally developed, flat-lying foliation (schistosity and gneissosity, S_1) was formed at generally high metamorphic grades that reached upper amphibolite to granulite facies. Partial melting, especially of pelites and semipelites, was widespread and generally outlasted tectonism. This event was pervasive throughout the whole of the Mudjatik Domain. Genetically related folds or repetitions of supracrustal zones around any given dome or basin were not recognized during the

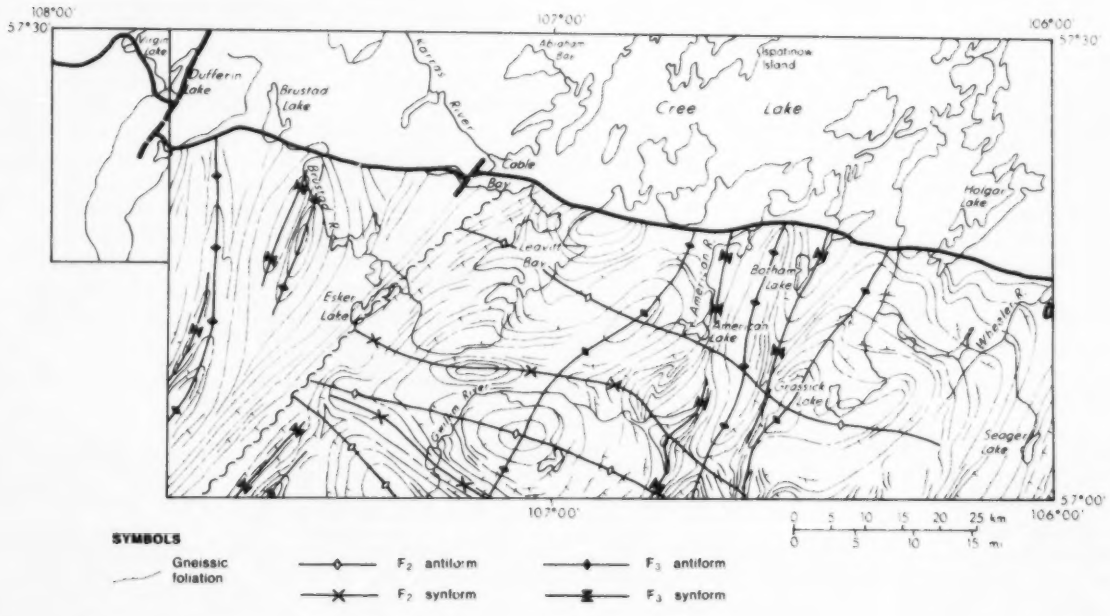

Figure 9. Generalized structural trends

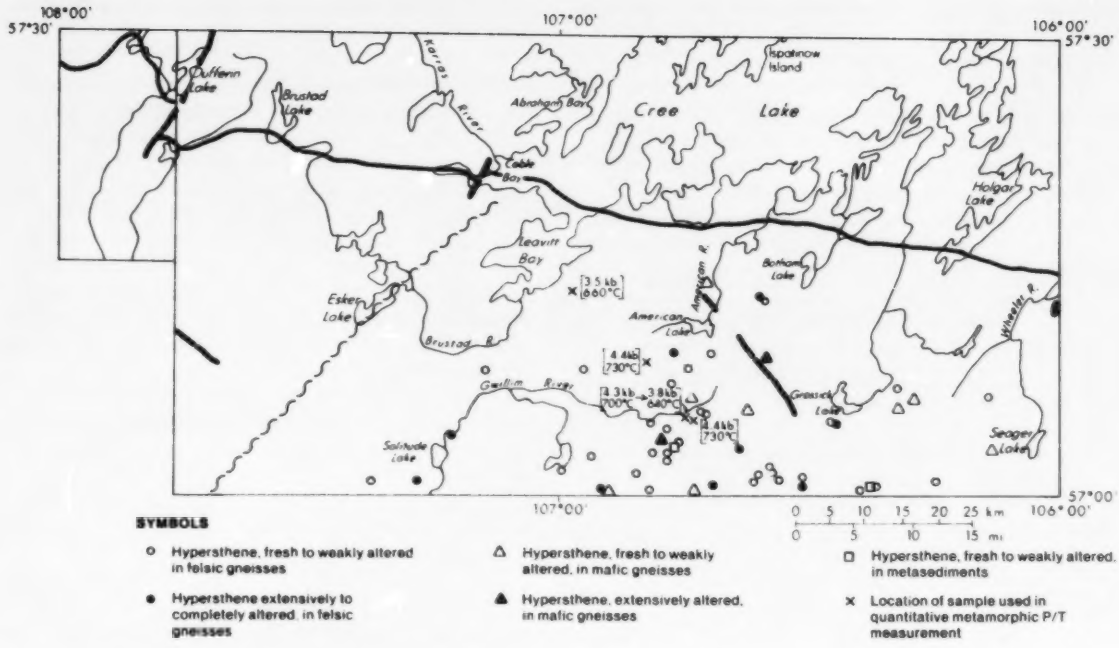

Figure 10. *Distribution of hypersthene, and locations of samples used for quantitative measurement of metamorphic conditions*

present study. Lewry and Sibbald (1980), however, felt that both major and minor coeval isoclines were responsible for the occurrence, within Mudjatik Domain felsic gneisses, of supracrustal zones at different structural levels (best developed in the southeastern corner of the domain).

In the Wollaston Domain, the earliest metamorphic minerals in the possibly Archean granitoid gneisses include biotite, hornblende, quartz, plagioclase (mostly An_{15-25}) and well-developed microperthitic microcline. Biotite, amphibole, quartz, plagioclase (mostly An_{30-50}) and weakly developed microperthitic microcline, together with minor diopside and scapolite in the more calcareous rocks, are dominant in the pelites and semipelites. Sillimanite is rare, occurring in trace amounts within other minerals. Garnet and cordierite are recognized only in a few concordant mobilizate veins. Calc-silicate rocks usually contain scapolite and/or diopside, biotite and microcline. Upper amphibolite facies metamorphic conditions are indicated.

Felsic gneisses of the Mudjatik Domain contain hypersthene in addition to the minerals found in the Archean granitoid gneisses of the Wollaston Domain (see preceding paragraph). Although hypersthene is almost always present in mafic gneisses along with hornblende, diopside and plagioclase (An_{35-70}), it is rare in the metasediments. In the pelites and semipelites of the Mudjatik Domain, biotite, garnet, cordierite, sillimanite, quartz, plagioclase (An_{23-43}) and microperthitic (often intense) microcline are abundant and spinel occurs locally. Large volumes of mobilizate in the metasediments are now represented by early deformed concordant veins, generally up to 25 cm wide, as well as by late massive cross-cutting pegmatitic dykes up to 5 m wide. Both early and late mobilizates contain abundant sillimanite, garnet and cordierite. Medium pressure upper amphibolite to granulite facies metamorphism is sugggested. Nielsen (personal communication), on the basis of four samples (0151, 0187, 0191, 0192) collected during this survey, quantitatively evaluated the conditions that prevailed during regional metamorphism. His tentative results, which indicate the existence of at least two distinct pressure/temperature regimes, are presented in Table 22. In the earlier regime, Fe and Mg distribution between garnet and cordierite seemingly stabilized at about 4.3 to 4.4 kbars and 700 to 730°C.

Table 22. Quantitative evaluations of P/T conditions prevailing in the central part of the Mudjatik Domain during Hudsonian regional metamorphism

Dept. No. (7708-)	*P (kbars)*		*T (°C)*
0151	3.5	**	660
0187	4.4	*	730
0191	4.4	*	730
0192	4.3	*	700
	3.8	**	640

* P/T conditions during D_1 peak

** P/T conditions possibly during late D_3

In the Virgin River Domain, the granitoid gneisses lack both pyroxene and hornblende, and are composed mainly of biotite, quartz, plagioclase (generally An_{18-25}) and microcline (commonly microperthitic). The metasediments contain early biotite, garnet, sillimanite, quartz, plagioclase (An_{15-60}) and, occasionally, microcline. They are, for the most part, little migmatized. Medium pressure, middle to upper amphibolite facies conditions prevailed.

Second and Third Thermotectonic Events (D_2, D_3)

The regional foliation (S_1) was deformed by upright northwesterly and northeasterly trending folds that produced regional dome-and-basin structures. These generally have a slight to pronounced north to northeasterly elongation. Minor structures of this type 1 interference pattern (Ramsay, 1967) are extremely rare in the map area; only one set has been seen in an exposure 3 km north-northwest of Mudjatik Lake. The age relationships between the two events (D_2, D_3) responsible for the interference structures were not established during this survey, but Pearson and Lewry (1974) and Lewry and Sibbald (1977, 1980) have suggested that the northwesterly folds of D_2 age are earlier than the northeasterly set (D_3). Large- and small-scale structures in the Black Birch Lake region, which lies a short distance to the south of this map area, seem to confirm their proposed sequence. In the absence of conflicting evidence, their proposal is followed in this report (Figure 9).

Major structures of D_2 age are well developed in the Mudjatik Domain, but associated minor structures were not widely recognized. D_2 structures do not, however, greatly influence outcrop patterns or structural trends in the Wollaston and Virgin River Domains (see also Gilboy, 1975; Lewry, 1977; Lewry and Sibbald, 1980; Ray, 1975, 1977; Wallis, 1971), where the northerly to northeasterly linearity of structural grain is intensified. In the Wollaston Domain, doubly plunging folds (not present in the Cree Lake South area) are considered by Lewry and Sibbald (1980) to be D_3 structures lacking D_2 influence. However, they consider folds of closely comparable style in the Virgin River Domain to be produced by D_2/D_3 superimposed deformation. D_3 has undoubtedly controlled structural patterns and trends to a greater extent than D_2. Moreover, D_3 minor folds, commonly with an axial planar schistosity and generally asymmetric, are abundant throughout the map area.

Metamorphic conditions in the region seem to have remained constant after peaking during D_1, because some mobilizate veins truncate the D_3 minor structures in the pelites and semipelites. These late veins contain the same metamorphic index minerals (cordierite, garnet and sillimanite) as the D_1 mobilizate segregations, indicating that medium pressure, upper amphibolite facies metamorphic

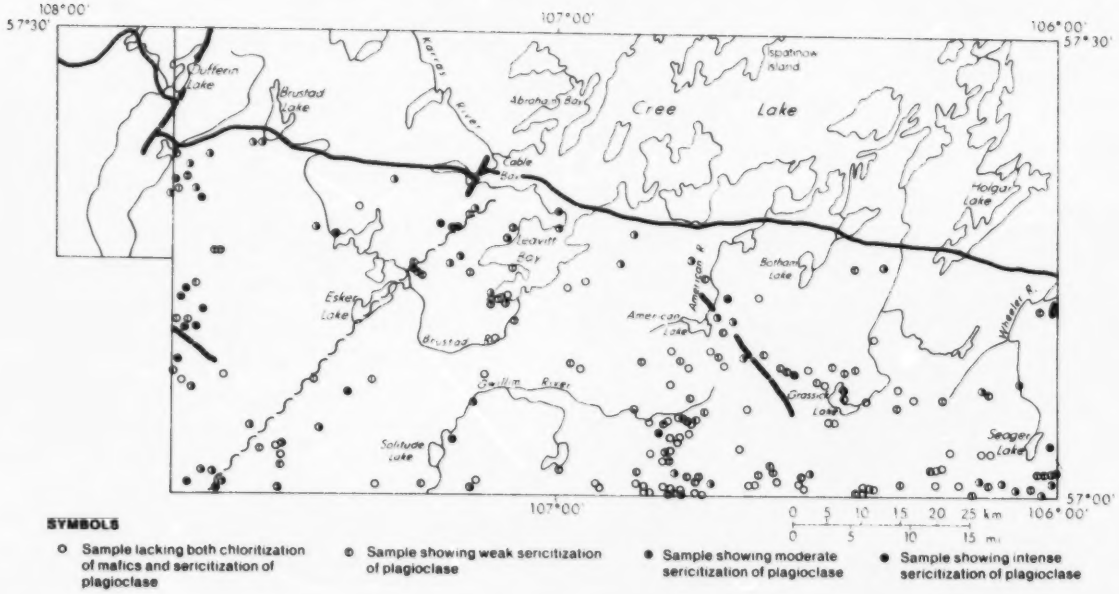

Figure 11. Relative degree of plagioclase sericitization

conditions prevailed. No hypersthene was seen that could confidently be assigned to post-D_3 generation. Lewry and Sibbald (1977, 1980) envisage a metamorphic history for this part of the Saskatchewan Precambrian Shield similar to that outlined here.

Nielsen (personal communication) has found evidence of late elemental re-equilibriation between co-existent minerals in several of the Mudjatik Domain metasediments (Table 22). The pressures and temperatures involved were 3.5 to 3.8 kbars and 640 to 660°C (middle to upper amphibolite facies), and were probably related to the late static stages of the D_3 event. Biotite probably recrystallized during the event, both mimetically around D_3 fold hinges and randomly.

Fourth Thermotectonic Event (D_4)

Localized tectonism and metamorphism continued after the main development of the presently observed tectonothermal pattern, producing ductile shearing associated with and succeeded by retrogression of the affected rocks to greenschist facies. Although retrograde metamorphism is widespread throughout the Virgin River Domain and along the western edge of the Mudjatik Domain (Figures 11 and 12), it is most evident along and adjacent to the Cable Bay Shear Zone, which Lewry and Sibbald (1980) consider to be the result of accommodation during D_3 flattened flexural folding. It is responsible for strong plagioclase sericitization, as well as for the development of very late cross-cutting flakes of biotite, muscovite and chlorite. Sericitization and chloritization also occur sporadically throughout the central and eastern parts of the Mudjatik Domain, and sericitization is widespread in the Wollaston Domain. The extent to which quartz is strained increases from east to west; particularly intense straining occurs near the Cable Bay Shear Zone (Figure 13). Ribboned quartz is largely confined to the shear zone, but several examples have been found close to the Wollaston/Mudjatik boundary (sample 0082) and in the central Virgin River Domain (sample 0136).

Minor folds of D_4 age, similar to those described by Lewry and Sibbald (1980), have not been recognized anywhere in the map area.

Neither the Athabasca sediments nor the diabase dykes have been affected by the D_4 event. The formation of biotite and amphibole from pyroxene and the sericitization of plagioclase in the diabase dykes are probably late-stage hydrothermal in origin.

Regional Fractures

Late brittle fractures are reflected by large topographic lineaments, 1 to 9 km long, that can be easily seen on aerial photographs. Four trends are evident: the best developed set trends northwest while three less distinct sets trend east to east-southeast, north-northwest and north-northeast.

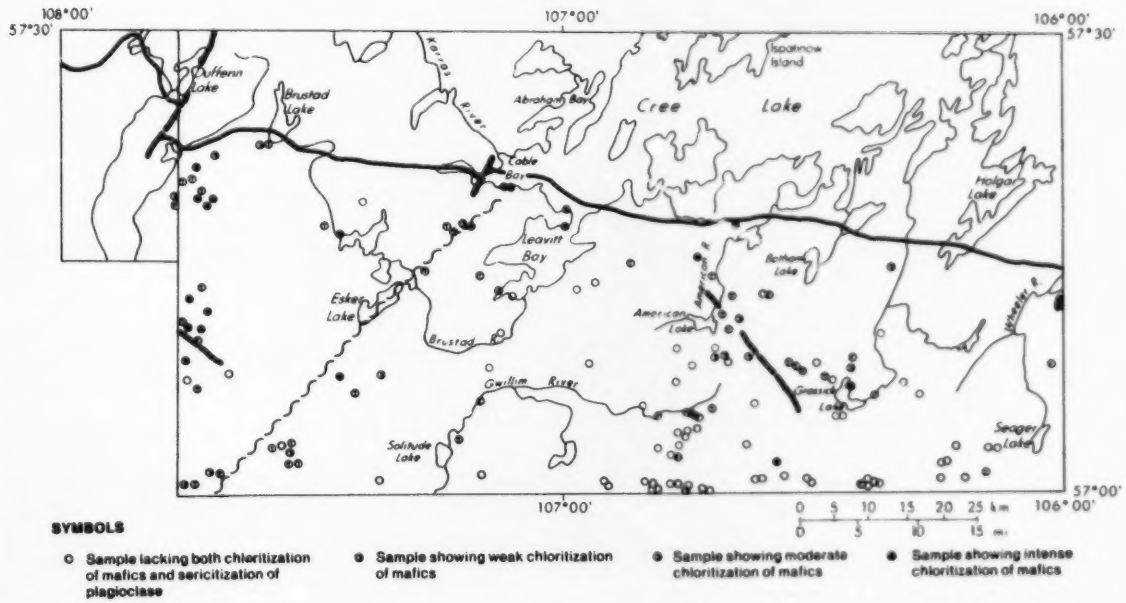

Figure 12. Relative degree of biotite chloritization

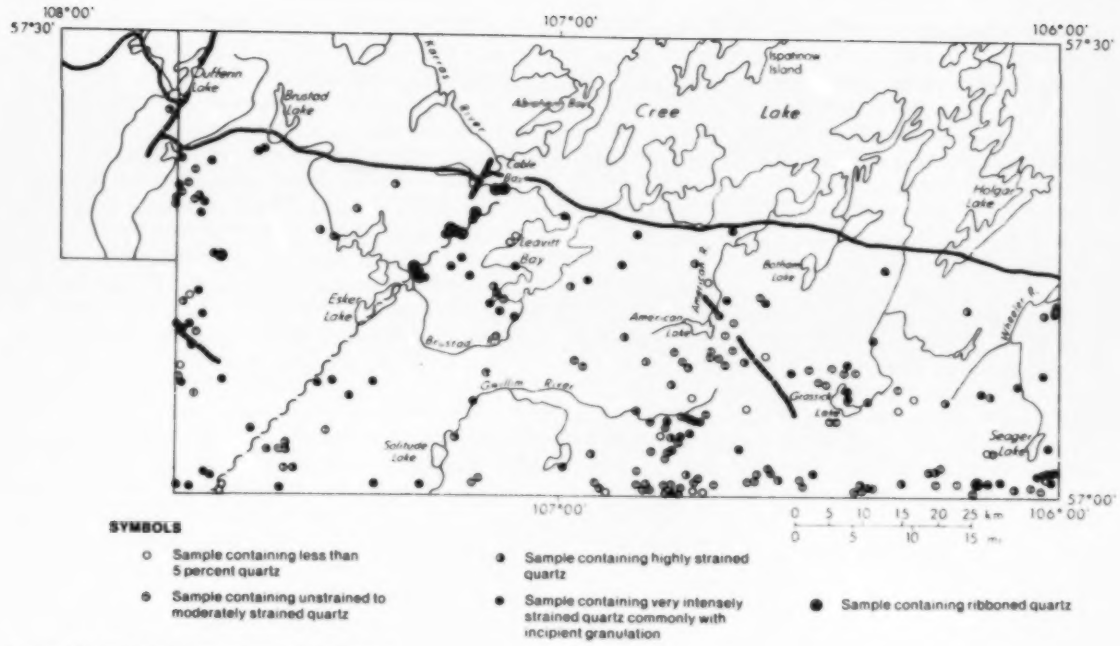

Figure 13. *Relative degree of quartz deformation*

There is generally no evidence of fault movement along these fractures, but about 7 km west of Grassick Lake, a metasedimentary band has an apparent sinistral offset of about 1.5 km, along a southeasterly extension of a southeast-trending fracture. Also, 4 km east of Nyberg Lakes, a similarly trending fracture appears to have a small sinistral offset of several hundred metres. A fault also offsets the southern edge of the Athabasca Group south of Dufferin Lake; the southeastern side has been downthrown by an undetermined amount.

Summary of Geological History

Felsic gneisses, probably Archean in age, form the dominant rock type throughout the map area. In the east (part of the Wollaston Domain), they are compositionally and texturally homogeneous, and may initially have been injected during a period of late Archean magmatism at about 2500 Ma (Ray and Wanless, 1980). In the centre (part of the Mudjatik Domain), the felsic gneisses commonly resemble the eastern "magmatic-type" homogeneous gneisses and have yielded a "scatterchron" which indicates a possible Archean age (Bell, personal communication, 1980). However, inhomogeneous felsic gneisses are also abundant; these include hornblende-bearing banded migmatites which may have been derived from supracrustal rocks. In the west (part of the Virgin River Domain), the felsic gneisses are relatively homogeneous, but in many places have lost their early tectonically imposed planar fabrics because of recrysallization and/or remobilization.

Supracrustal rocks of the Wollaston Group structurally overlie probable Archean granitoid basement in the eastern part of the area. Mafic gneisses are poorly represented, calc-silicates are well represented and quartzites are absent; other metasedimentary rock types are tourmaliniferous. All contain only small amounts of segregated mobilizate. In contrast, supracrustal rocks in the central region (Mudjatik Domain) occur as bands sandwiched between felsic gneisses. Mafic gneisses are moderately well represented. Calc-silicate rocks are found only as rare boulders in the eastern half of the region; in the western half, they seem to be absent, apparently having given way to quartzites. Metasediments are virtually free of tourmaline and are highly migmatized.

Lewry and Sibbald (1980) correlate the supracrustals of the Wollaston Domain with those of the Mudjatik Domain and thus assume the latter to be Aphebian in age. Their arguments are essentially supported by the present study despite the above-mentioned differences between the supracrustals of the two domains. Lewry and Sibbald (1980) further argue that an essential geological continuity exists between the Mudjatik and Virgin River Domains; consequently, they deduce that the supracrustal rocks in the Virgin River Domain are also Aphebian in age. Supracrustals in that part of the Virgin River Domain lying within the map area contain an abundance of mafic gneisses, no calc-silicates and locally plentiful quartzite. Tourmaline occurs sporadically and cordierite is absent. The gneisses are characterized by an almost complete lack of migmatization and widespread greenschist facies retrogressive metamorphism.

Prior to or during the initial phases of the Hudsonian orogeny, tonalitic to monzogranitic plutons were emplaced, mainly along or close to the Cable Bay Shear Zone which, in the map area, separates the Mudjatik and Virgin River Domains. This concentration is perhaps indicative of the long-standing geological history of the shear zone and its importance as a zone of crustal weakness. One of the plutons, the Barr Lake ferrohastingsite-bearing megacrystic metamonzogranite, resembles the 1720 Ma Junction Granite (Lewry and Sibbald, 1980; Bell, personal communication, 1980) and the 1865 Ma Wathaman-Chipewyan Batholith (Ray and Wanless, 1980), both in appearance and in tectonic setting. However, it contains a folded, early tectonic planar fabric (S_1), suggesting that it may be older.

Hudsonian polyphase deformation and metamorphism has affected all of the pre-Helikian rocks in the area except the late massive granitoid intrusives. The earliest recognizable event (D_1) was responsible for the regional development of a flat-lying gneissosity and/or schistosity. All primary structures were destroyed except, possibly, depositional layering in sediments. This apparent preservation may account for much of the compositional and textural variation now seen in the metasediments. No D_1 structures were recognized, though they have been reported elsewhere (Lewry and Sibbald, 1980). Conditions were typical of upper amphibolite to granulite facies regional metamorphism. In the Mudjatik Domain, Fe/Mg partitioning between co-existent biotite, garnet and cordierite indicates that pressures of 4.4 kbars and temperatures of about 725°C were attained (Nielsen, personal communication, 1980). These metamorphic conditions, which caused extensive migmatization especially in Mudjatik Domain metasediments, appear to have remained fairly steady throughout the succeeding two deformational events, D_2 and D_3. These latter events were responsible for the large northwest- and northeast-trending upright folds (Lewry and Sibbald, 1977, 1980). The resultant dome-and-basin interference pattern is particularly well seen in the southern part of the Mudjatik Domain (south of the map area). Most minor structures in the map area appear to be genetically related to D_3; they rarely interfere with D_2 minor structures. In the Mudjatik Domain, late Fe-Mg re-equilibration between biotite, garnet and cordierite took place at about 3.7 kbars and 650°C (Nielsen, personal communication, 1980).

Following the cessation of major deformation, granite was once more emplaced in the form of recognizable plutons and plugs in the western part of the Mudjatik Domain and in the Virgin River Domain. In the Virgin River Domain, widespread recrystallization or remobilization of felsic gneisses destroyed earlier tectonic fabrics. In the eastern half of the map area, this period of intrusive activity gave rise to numerous cross-cutting, randomly oriented dykes generally

less than 4 m wide; only one plug of mappable dimensions was found.

The effects of late shearing (D_4) are most apparent in the west, where quartz grains in all rock types are usually highly strained. The most extreme deformation is confined to the 0.2 to 0.3 km wide northeast-trending Cable Bay Shear Zone. D_4 was accompanied and followed by middle to upper greenschist facies metamorphism.

Uplift, erosion and deep weathering (to a depth of about 50 m) took place prior to deposition of fluvial detritus which filled the eastern half of the the Athabasca Basin (Ramaekers, 1979) at about 1350±50 Ma (Ramaekers and Dunn, 1977). The Athabasca Group is typical of a molasse sequence in all aspects except the apparent chemical maturity of the sediments. This maturity may be the result of a long diagenetic history of the sediments rather than a primary feature (Ramaekers, 1979). Two main river systems appear to have drained into the part of the Athabasca Basin situated immediately north of the map area. Paleocurrent directions east of Cable Bay generally trend towards the west and rarely towards the north. The associated conglomerates and clastic sediments are tentatively placed by Ramaekers (1977) in his 'Ahenakew deposystem'. Because of a systematic difference in paleocurrent patterns and grain-size distribution northwest of Cree Lake (and therefore northwest of the Cable Bay Shear Zone), Ramaekers has suggested that the sediments are part of a different (Karras) deposystem.

Diabase dykes were injected into both the crystalline basement and the Athabasca Group rocks at about 925 to 1250 Ma (Tremblay, 1378; Burwash et al., 1962). Exposures of the diabase are, for the most part, restricted to the Athabasca Basin and only rarely occur in the crystalline regions of the map area. Evidence from boulders, however, suggests that the Cree Lake dyke swarm extends southeast into the basement.

Environments favourable for uranium mineralization occur in places along the southern edge of the Athabasca Basin. Elsewhere, diagenetic-hydrothermal uranium metallogenesis has been radiometrically dated at between 1050 Ma for Cluff Lake (AMOK (Canada) Limited, 1974) and 1200 Ma for Key Lake (Wendt et al., 1978). This mineralization is similar in age to the diabase dykes.

Regional fracturing and faulting occurred along four main trends: north-northeast, northeast, east to east-southeast, and south-southeast. Their chronological relationship to other (post-Hudsonian) geological events is unknown, although some north-northeast-trending faults, such as that immediately east of Dufferin Lake, clearly offset Athabasca Group sediments and possibly the Cree Lake Dyke Swarm (Ramaekers, 1977).

Striae, long axes of drumlinoid ridges and esker trends together show that the last Pleistocene ice front moved from the northeast (035° to 040°). As it retreated, a ground moraine was deposited over much of the area. A wide, indistinct recessional moraine, the product of a minor readvance, lies between Blanchard Lake in the east (where it is largely obliterated by outwash sands) and north of Brustad Lake in the west. A glacial Cree Lake, whose areal extent and detailed history are unknown, doubtless existed.

Finally, eolian deposits were sporadically distributed across the map area as northwest-trending linear or hyperbolic dunes; most of the hyperbolic dunes close to the northwest. Wind fluting on the southeast sides of rock exposures is common and indicates a wind direction similar to that indicated by the dunes (i.e. 125°±10°).

Economic Geology

Until the current intense search for uranium, the Mudjatik and Wollaston Domains in this map area received little attention in terms of exploration. More interest was shown in the Virgin River Domain, particularly to the west of the map area, because of copper, copper-nickel and rare gold showings. Within the map area, the Nyberg Lakes iron deposit is one of the most important known mineral occurrences. Although it has been economically evaluated several times, it is presently unviable.

Uranium

The contact between the Athabasca Group and the underlying basement provides a favourable environment for uranium mineralization, especially where the basement consists of graphite-bearing Wollaston Group lower pelites. The pelites are thought to have an important role in the formation of Key Lake-type U-Ni ore deposits (Ray, 1977; Hoeve and Sibbald, 1978, 1979).

Because so little of the area lies within the Wollaston Domain, the most suitable exploration targets are limited to the area extending from west of Holgar Lake eastwards to Wheeler Lake. This ground is of particular interest for uranium exploration because of indications, from both boulder and structural evidence, that the near-basal Wollaston Group graphitic metasediments lie immediately south of, and presumably below, the Athabasca Group for a distance of about 14 km.

Lewry and Sibbald (1980) feel that the supracrustal rocks in the Mudjatik Domain can be correlated with the Wollaston Group metasediments. If their argument is accepted, then another suitable target zone for Key Lake-type deposits is located south of Lazy Edward Bay. No indications of other supracrustal bands were found close to, or striking beneath, the southern edge of the Athabasca Group, except for (a) a single very small boulder of garnet-cordierite-sillimanite-biotite pelite, located midway between Blanchard and Brownfield Lakes and (b) a 10 cm well-rounded boulder of competent graphite-biotite semipelite, located close to the southeast shore of Blanchard Lake about 0.5 km north of the assumed southern edge of the Athabasca Group.

Between the Holgar-Wheeler Lakes zone and Brownfield Lake to the west, an area of anomalously radioactive boulders (up to 50 times background) was found 2 km southeast of Blanchard Lake. The boulders, some of which attain a diameter of about 3 m, consist of granitoid-derived regolith material and Athabasca Group conglomerate containing clasts of brown to black quartz (commonly clear) in addition to milky quartz. The anomalies (Ramaekers, personal communication, 1980) are probably caused by high thorium values since uranium contents were low.

Lewry and Sibbald (1980) suggest a lithologic, structural and metamorphic continuity between the Mudjatik and Virgin River Domains. The disappearance of the Virgin River Domain supracrustals beneath the Athabasca sediments probably marks areas that are favourable loci for uranium mineralization. Target zones thus defined include Cable Bay (southeast of the weather station) and the Westgate Lake-Dufferin Lake region.

Iron

Magnetite-rich iron formation, discovered 5 km east of the Nyberg Lakes in the early 1960s, was geologically and geophysically surveyed and drilled by Kenad Developments of Calgary. It was resurveyed during the provincial Mineral Evaluation Program. Results have shown that:

a) the iron formation crops out as a discontinuous band (five main ore lenses) in the southern and western core zones of a structural basin; associated metasediments include pelites and garnetiferous quartzites;
b) the deposit thins at depth; and
c) mining to a depth of 150 m, would produce ore reserves of about 23 to 27 million metric tons grading 32 percent iron.

Harper (1983) considers that the deposit is presently uneconomic because of its overall low grade and inaccessibility.

A single outcrop of iron formation occurs within the felsic gneisses of the Mudjatik Domain. However, because of lack of continuity along strike, this occurrence is of only limited interest.

Other Work (Non-Confidential)

Prior to 1973, most exploration work in the map area was concentrated in the Virgin River Domain. One area, the VH deposit, has already been described. In the second area, close to Dufferin Lake, seven diamond-drill holes were put down, three by Cazun Exploration Company in 1968 and the remainder by Worldwide Energy Company Limited in 1969/70. None gave economically encouraging intersections.

To the east in the Mudjatik Domain, Athabasca Columbia Mining Limited drilled two 30 m holes in 1969 on a weak radioactive anomaly in felsic gneisses close to the west end of Brownfield Lake. No anomalous uranium or thorium values were found.

A molybdenite showing, marked on Geological Survey of Canada Map 1007A (Rice, 1951) 4 km southwest of Huston Lake, was not relocated during this survey. The few exposures seen in this area consist of homogeneous felsic gneisses of Unit MFa, several large boulders of which contain cross-cutting, magnetite-bearing pegmatites.

Summary

Apart from the possible target areas for uranium and associated metals, the map area appears to have little economic potential. Although the VH iron deposit is not presently viable, it could become economic with changing market conditions.

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Appendix A: Abbreviations and Symbols Used in Modal Composition Tables

Mineral abbreviations:

Ap	Apatite
Bt	Biotite
Cbt	Carbonate
Chl	Chlorite
Co	Cordierite
Di	Diopside
Ep	Epidote
Gr	Graphite
Gt	Garnet
Hb	Hornblende
Hyp	Hypersthene
Ms	Muscovite
Mz	Monazite
Op	Opaque minerals (undifferentiated)
Pg	Plagioclase
Qz	Quartz
Se	Sericite
Serp	Serpentine
Sill	Sillimanite
Sph	Sphene
To	Tourmaline
Zo	Zoisite
Zr	Zircon

Descriptive symbols and abbreviations:

–	Well-developed S_1 dimensional orientation
~	Weak S_1 dimensional orientation
∿	S_1 dimensional orientation folded
~	Weak secondary (S_2 or later) dimensional orientation
·	Random orientation
	Mineral (especially cordierite or garnet) full of inclusions which define no internal planar fabric
⁻	Mineral (especially cordierite or garnet) full of inclusions which define an internal planar fabric
˙	Mineral (especially quartz) highly strained
:	Mineral (especially quartz) very intensely strained and commonly showing incipient granulation
ˣ	Microcline (or plagioclase) with intense development of microperthitic exsolution lamellae (or antiperthitic exsolution)
ˢ	Microcline (or plagioclase) with moderate development of microperthitic exsolution lamellae (or antiperthitic exsolution)
*	Mineral (especially biotite, hypersthene or plagioclase) weakly altered
**	Mineral (especially biotite, hypersthene or plagioclase) moderately altered
***	Mineral (especially biotite, hypersthene or plagioclase) extensively altered
****	Mineral (especially hypersthene) completely altered
Tr	Mineral present in only trace amounts
(ab)	Accessory mineral relatively abundant
(r)	Accessory mineral relatively rare
? or (?)	Mineral identification uncertain

Appendix B: Analytical Techniques

Geochronological Samples[1]

Samples were crushed to less than 100 mesh using a jaw-crusher and a tungsten carbide Bleuler mill. Rb/Sr ratios and Rb and Sr abundances were measured by X-ray fluorescence using the United States Geological Survey standard G-2. The mass absorption coefficients of the unknown were measured directly using the method of Norrish and Chappell (1967), and these were then used to determine concentrations. The estimated precision at the 2σ level is ± 2 percent for the abundances above 20 ppm and ± 2 percent for the Rb/Sr ratios.

Samples were prepared for isotopic analysis by means of a hydrofluoric-perchloric acid dissolution, followed by separation of Rb from Sr using ion-exchange columns. The Sr was run in the form of the nitrate using a single rhenium filament. The Sr isotopic analyses were carried out on a 15 cm 90° mass spectrometer. Operation of the mass spectrometer, including data reduction, was controlled by a PDP-11 computer. The ion beam was amplified by an electron multiplier in conjunction with a Cary Model 31 vibrating reed electrometer. Precision of the $^{87}Sr/^{86}Sr$ ratios is 7 parts in 7000 at the 95 percent confidence level. The Eimer and Amend Sr standard gave a value of 0.7077 ± 0.0002 during the course of this work.

Slopes and intercepts for the isochrons were determined using the method of York (1969) and the ages calculated using the new decay constant for ^{87}Rb of $1.42 \times 10^{-1} y^{-1}$ (Steiger and Jager, 1977). All isochron uncertainties are quoted at the 2σ level. Together with the isochron data, a mean square of the weighted deviates (MSWD) is computed; this is an indication of the 'goodness-of-fit' of the data points to a straight line (Brooks et al., 1972). In the ideal case, the MSWD approaches a value of 1 if the points fit the line within experimental uncertainty. The MSWD is also dependent on the number of points defining the isochron. For the results presented in this report, any MSWD less than 5 implies that the isochron model is a valid interpretation of the data.

[1]K. Bell, Carleton University, Ottawa, Ontario

Geochemical Samples[2]

Samples were initially broken up with a hammer and then passed through a jaw crusher (with carbon steel jaws to eliminate Ni, Cr or Co contamination) which reduced them to chips of 0.5 cm or less. This material was quartered, the larger fraction being stored and the smaller fraction crushed to -120 mesh in a Spex shatterbox mill.

Approximately 3 g of the powder was heated at 120°C for 8 hours in preheated vitreosil crucibles and then at 950°C for a further 8 hours. The weights at these temperatures were used to determine hygroscopic water (H_2O^-) and loss-on-ignition (LOI) respectively. Small portions (0.28 g) of the ashed sample material were used to make fusion discs for major element analysis according to the method of Norrish and Chappell (1967). The flux used was Chemplex Grade III X-ray fusion flux (catalogue no. 925), consisting of 47 percent lithium tetraborate, 37 percent lithium carbonate and 16 percent lanthanum oxide. All major elements (or oxides) except sodium and phosphorus were determined on the fusion discs using a Philips PW 1540 manual spectrometer with a 2 KW generator. Ferrous iron was determined titrimetrically using the method outlined by Hutchison (1974).

Approximately 6 g of powder was moistened with a 1 percent PVA solution to improve cohesive qualities of the oversaturated rocks and briquetted in Spex aluminum cups (catalogue no. 3619) at a pressure of 12 tons. Sodium, phosphorus and all trace elements were determined on these whole rock powder pellets using the same spectrometer.

All analyses were carried out in duplicate and sets of international standards were determined at least 4 to 6 times during any particular run. In order to obtain a quantitative check on precision in instrument operation (and sample preparation) eleven fusion discs and pellets of a laboratory standard were also analyzed. The mean, standard deviation and coefficient of variation for each element and oxide determination could then be calculated for a particular run.

[2]B. Watters, University of Regina, Regina, Saskatchewan

Saskatchewan Energy and Mines

Saskatchewan Geological Survey

REPORT 132

LEGEND

QUATERNARY

Q — **Boulder tills, moraines and glaciofluvial sands and gravels**

UNCONFORMITY

PRECAMBRIAN

PROBABLE GRENVILLIAN INTRUSIVES

Diabase, dark green, medium to coarse grained, massive, subophitic

HELIKIAN SEDIMENTS

AG — **Athabasca Group**[1], mostly white or pale pink, well-bedded, flat-lying sandstones of variable grain size

UNCONFORMITY

MUDJATIK DOMAIN:

PROBABLE LATE HUDSONIAN INTRUSIVE

Leucogranite (containing less than 5 percent biotite), moderate to pale pink, medium to coarse grained, massive to poorly foliated

PROBABLE EARLY AND MIDDLE HUDSONIAN INTRUSIVES

Metamonzogranite (containing 5 to 10 percent biotite ± ferrohastingsite and abundant microcline megacrysts up to 4 cm long), pale pink, coarse grained, well foliated

MFT, MFG — **Metatrondhjemite, metatonalite and metagranodiorite** (containing 5 to 20 percent biotite ± hornblende), white to pink, medium to coarse grained, well foliated to (rarely) massive, typically homogeneous on regional scale but containing possible xenolithic patches on detailed scale

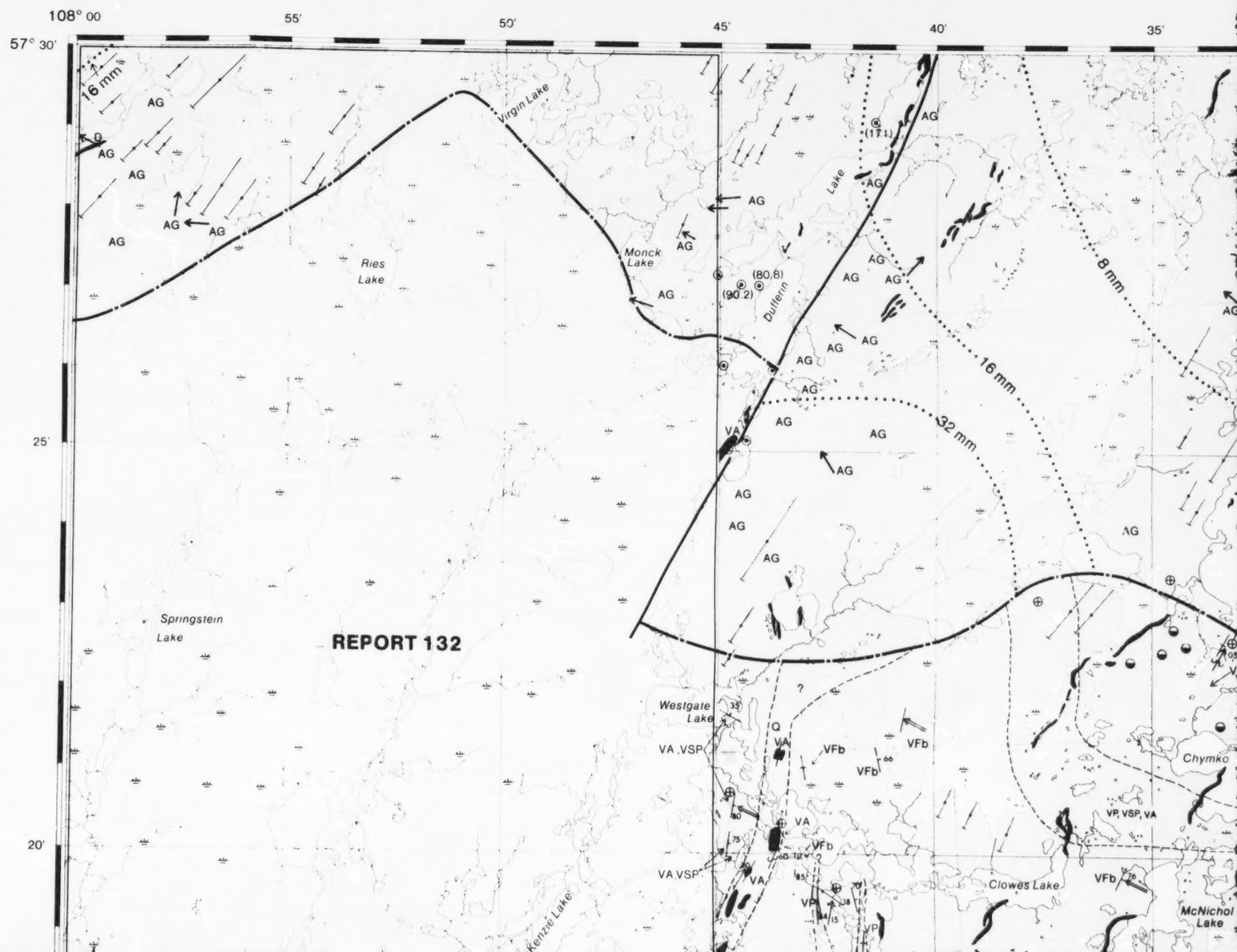
POSSIBLE APHEBIAN SUPRACRUSTALS

MQ — **Metaquartzite**, generally containing biotite and muscovite

MPMSPMPS — **Pelitic, semipelitic and psammitic gneisses**, ± biotite ± cordierite ± garnet ± sillimanite ± graphite

Amphibole gneisses, containing 30 to 70 percent hornblende ± greenish hypersthene ± diopside

MwFC — **Charnockitic felsic gneisses** (typically containing 5 to 10 percent biotite ± hornblende + hypersthene (commonly intensely altered) and small microcline megacrysts), homogeneous, waxy reddish brown, medium to coarse grained, well foliated



35′ 30′ 25′ 20′ 15′ 10′ 05′ 107° 00′

57° 30′

25′

20′

Karras Lake

Abraham Bay (Cree Lake)

Warnes Lake

Karras River

MacKenzie Bay (Cree Lake)

MacKenzie Bay

Brustad Lake

Chymko Lake

McNichol Lake

Warr Lake

Andres Lake

Cree Lake

Cable Bay

Weather station

8 mm

16 mm

32 mm

AG

VFc

VFb

VG,VFa

VP, VSP, VA

VQ

Q

MFd

D

Geological boundary (defined, appro concealed)

Edge of Athabasca Group (approxi

Grain-size contours in Athabasca G

Shear zone (defined, concealed)

Fault or major airphoto lineament in fracture

Minor airphoto lineaments interpret gneissosity

Gneissosity and schistosity, first te vertical, horizontal, dip unknown)

Plunge of lineation or minor fold hing event (inclined, M-fold, S-fold, Z-fold

Paleocurrent direction in Athabasca

Glacial striae

Erratic boulders useful in geological Athabasca Group conglomerate (ma 16 mm), regolith, pelite)

Recessional moraine (approximate)

Esker

Drumlinoid ridge

Wind fluting

Sand dunes

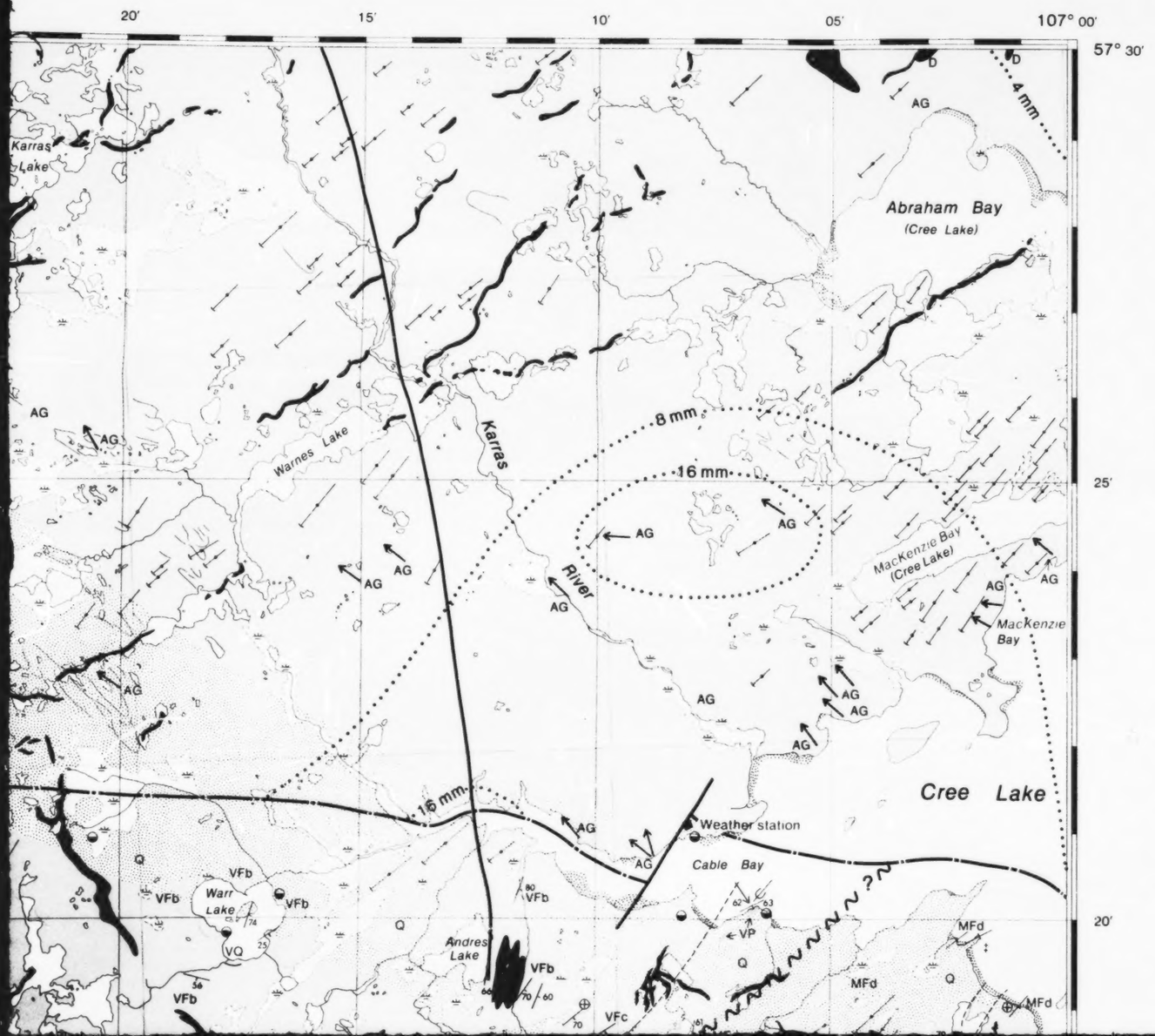
Muskeg

Intermittent lake

MAP 203A (SHEET 1)

BASEMENT GEOLOGY, PART OF THE CREE LAKE (SOUTH) AREA

NTS AREA 74G-S W (Part of)



SYMBOLS

- Geological boundary (defined, approximate or inferred; concealed)
- Edge of Athabasca Group (approximate)
- Grain-size contours in Athabasca Group ..... 4 mm .....
- Shear zone (defined, concealed)
- Fault or major airphoto lineament interpreted generally as master fracture
- Minor airphoto lineaments interpreted generally as early gneissosity
- Gneissosity and schistosity, first tectonothermal event (inclined, vertical, horizontal, dip unknown) 87
- Plunge of lineation or minor fold hinge, second tectonothermal event (inclined, M-fold, S-fold, Z-fold) 20 33 45 68
- Paleocurrent direction in Athabasca Group
- Glacial striae
- Erratic boulders useful in geological interpretation (diabase, Athabasca Group conglomerate (maximum clast size greater than 16 mm), regolith, pelite)
- Recessional moraine (approximate)
- Esker
- Drumlinoid ridge
- Wind fluting
- Sand dunes
- Muskeg
- Intermittent lake

POSSIBLE APHEBIAN SUPRACRUSTALS

MP,MSP,MPS

Pelitic, semipelitic and psammitic gneisses, ± biotite ± cordierite ± garnet ± sillimanite ± graphite

Amphibole gneisses, containing 30 to 70 percent hornblende ± greenish hypersthene ± diopside

MAINLY POSSIBLE ARCHEAN BASEMENT

MwFC

Charnockitic felsic gneisses (typically containing 5 to 10 percent biotite ± hornblende + hypersthene (commonly intensely altered) and small microcline megacrysts), homogeneous, waxy reddish brown, medium to coarse grained, well foliated

MF

Felsic gneisses:

MFa, mainly syenogranitic to monzogranitic (containing about 5 percent biotite ± amphibole, as well as scattered microcline megacrysts 1 to 3 cm long), typically homogeneous, dark to moderate pink, medium to coarse grained, well foliated;

MFb, mainly monzogranitic to granodioritic (containing 5 to 10 percent biotite), pale pink, medium to coarse grained, poor to moderate foliation;

MFc, mainly monzogranitic to granodioritic (containing 5 to 10 percent biotite), pale pink, medium to fine grained, well foliated;

MFd, mainly tonalitic (containing 5 to 10 percent biotite, amphibole), pale pink or grey, medium grained, characteristically enclosing amphibole-rich blocks up to 5 m across, inhomogeneous

VIRGIN RIVER DOMAIN:

PROBABLE MIDDLE TO LATE HUDSONIAN INTRUSIVE

Leucogranite (containing less than 5 percent biotite), moderate to pale pink, medium to coarse grained, well foliated

Banded iron formation, magnetite rich, interlayered with biotite-grunerite-quartz-garnet rock and with pelitic garnet-biotite gneisses

PROBABLE APHEBIAN SUPRACRUSTALS (Virgin Schist Group)

VQ

Metaquartzite

VP, VSP

Pelitic and semipelitic schists and gneisses, ± biotite ± garnet ± sillimanite

Amphibole-rich schists and gneisses

MAINLY POSSIBLE ARCHEAN BASEMENT, HEAVILY REWORKED

VF

Felsic gneisses:

VFa, mainly monzogranitic (containing about 5 percent biotite and scattered microcline megacrysts 1 to 3 cm long), pink, medium to coarse grained, poorly to well foliated;

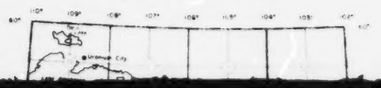
VFb, monzogranitic to granodioritic (containing 5 to 10 percent biotite), pale pink, medium to coarse grained, poorly to moderately foliated;

VFc, tonalitic to trondhjemitic (containing 5 to 20 percent biotite ± hornblende), pale pink or grey, medium grained, well layered, characteristically enclosing amphibole-rich blocks

[1] See Ramaekers (1977, 1979) and Gilboy (1980) for more detailed information on the stratigraphy of the Athabasca Group

Geological interpretation in areas covered by Quaternary glacial deposits is largely based upon geophysical data obtained from mineral exploration companies.

LOCATION MAP



Cree Lake

Chymko Lake

McNichol Lake

Brustad River

Warr Lake

Andres Lake

Gaucher Lake

Silt Lake

McIvor Lake

Moe Lake

Cosgrave Lake

Ubiquity Lake

Barr Lake

Island

Leavitt Bay (Cree Lake)

Jones Peninsula

Crockett Lake

McKie Lake

Carpenter Lake

Stony Narrows

Jerrold Lake

Esker Lake

Ballantyne Lake

Blazeiko Lake

Yunker Lake

Henderson Lake

(Calgar Lake)

Weedon Lake

Uzelman Lake

Mitchell Lake

Baker Creek

Leadbeater Lake

Henson Lake

Gourlay Lake

Zadworny Lake

Billings Lake

Strouts Lakes

Wood River

Barabonoff Lakes

Cable Bay

Weather station

15 mm

AG

VP

VP, VSP, VA

VG.VFa

VQ

MG

MG, MFb

MFb?

MFa

MFa, MwFC

MFa, MFd

MFb, MFd

MFd, MFb

MwFC, MFd

MSP, MP?

MFb, MFd

MFb, MFc

MFb, VG

VFb, VG

VFb, VFc

VFc, VG

VFb

VFc

MFd

MFb

MFa

MwFC

MFM

MFT

MSP

MP

MQ

Q

Esker

Drumlinoid ridge

Wind fluting

Sand dunes

Muskeg

Intermittent lake

EM Conductor

Diamond-drill hole (with
Group where relevant)

20'

15'

10'

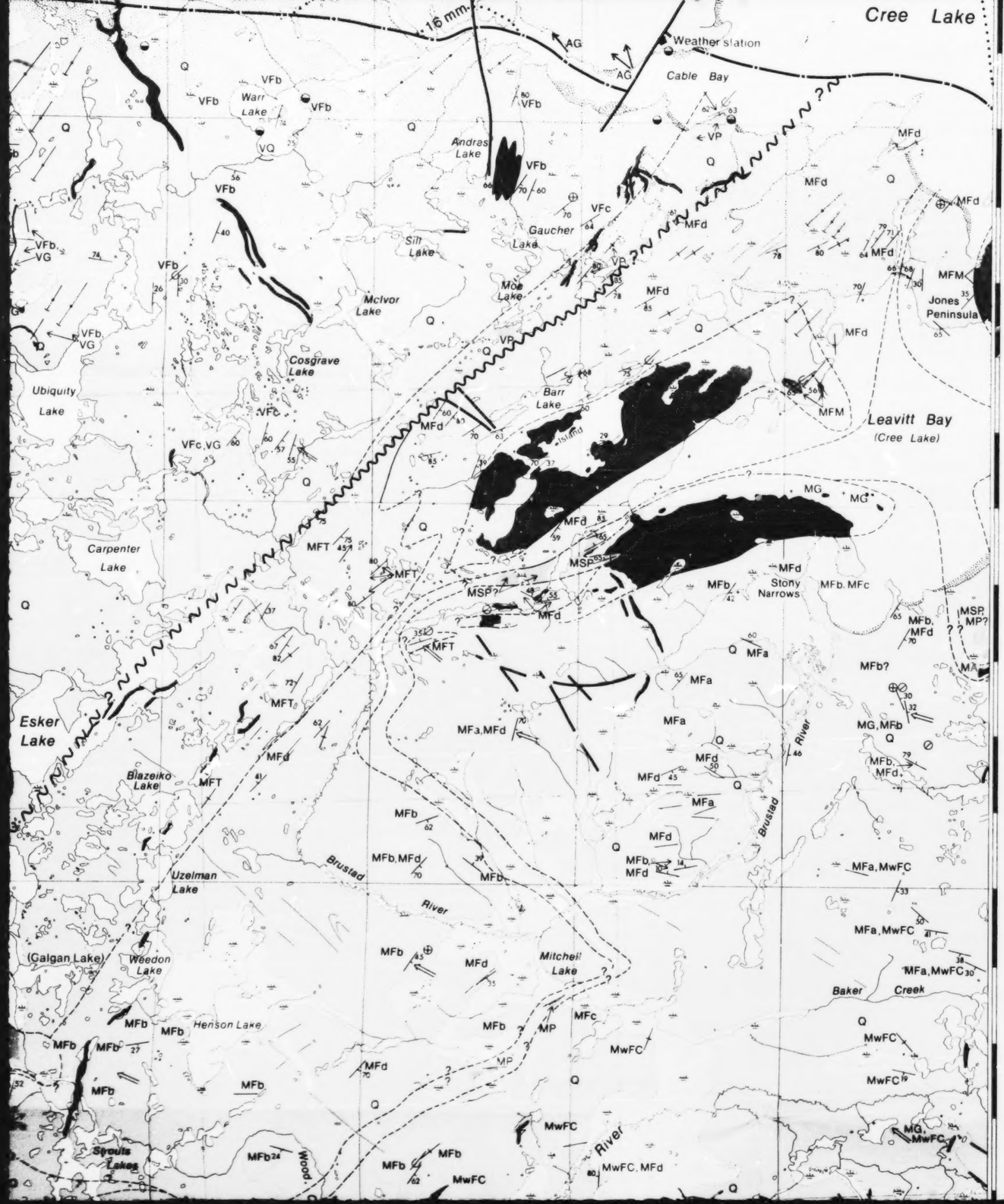
The geological surve
with funds provided
and Development A
veys.

Pre-Athabasca Gro
1977 by Christophe
D. Jones, Saskatche

Athabasca Group r
mapped in 1977 by
Wayne H. Pollard.

Cartography by R. C

Published in 1984



Esker

Drumlinoid ridge

Wind fluting

Sand dunes

Muskeg

Intermittent lake

EM Conductor

Diamond-drill hole (with depth in metres to base of Athabasca Group where relevant) ⊙(171)

100,000 M SQUARE IDENTIFICATION

GRID ZONE DESIGNATION 13V

CP

TO GIVE A REFERENCE TO NEAREST 1000 METRES

EXAMPLE	Weather Station
SQUARE Read letters of 100,000 m square	CP
EASTING Read number on grid line immediately to left of point	7
Estimate tenths of a square from this line eastward to point	2
	72
NORTHING Read number on grid line immediately below point	5
Estimate tenths of a square from this line northward to point	8
	58
MILITARY GRID REFERENCE (to nearest 1,000 metres)	CP 7258
If reporting beyond 18 in any direction prefix Grid Zone Designation as	13V CP7258

TEN THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 13

The geological survey leading to the production of this map was carried out with funds provided under the Canada-Saskatchewan Mineral Exploration and Development Agreement 1974-78, Reconnaissance Geoscience Surveys.

Pre-Athabasca Group rocks and overlying drift geologically mapped in 1977 by Christopher F. Gilboy (project leader), Roberta C. Bald and Barry D. Jones, Saskatchewan Geological Survey, Precambrian Geology Sector.

Athabasca Group rocks, Helikian intrusives and overlying drift geologically mapped in 1977 by Paul Ramaekers (project leader), Alfred A. Hartling and Wayne H. Pollard.

Cartography by R. O. Pearce.

Published in 1984 to accompany Saskatchewan Energy and Mines Report 203.

INTRUSIVE

PROBABLE APHEBIAN SUPRACRUSTALS (Virgin Schist Group)

MAINLY POSSIBLE ARCHEAN BASEMENT, HEAVILY REWORKED

Banded iron formation, magnetite rich, interlayered with biotite-grunerite-quartz-garnet rock and with pelitic garnet-biotite gneisses

VQ — **Metaquartzite**

VP, VSP — **Pelitic and semipelitic schists and gneisses**, ± biotite + garnet + sillimanite

Amphibole-rich schists and gneisses

VF — **Felsic gneisses:**

VFa, mainly monzogranitic (containing about 5 percent biotite and scattered microcline megacrysts 1 to 3 cm long), pink, medium to coarse grained, poorly to well foliated;

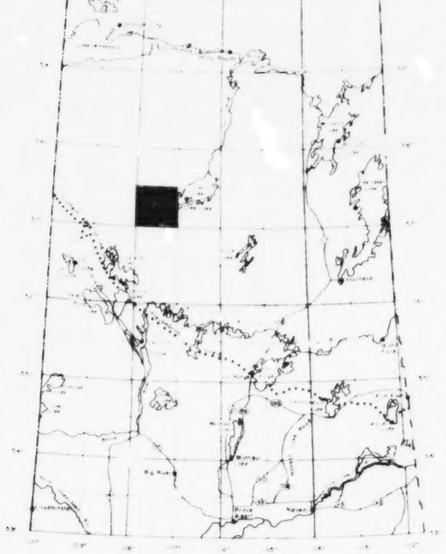
VFb, monzogranitic to granodioritic (containing 5 to 10 percent biotite), pale pink, medium to coarse grained, poorly to moderately foliated;

VFc, tonalitic to trondhjemitic (containing 5 to 20 percent biotite + hornblende), pale pink or grey, medium grained, well layered, characteristically enclosing amphibole-rich blocks

[1] See Ramaekers (1977, 1979) and Gilboy (1980) for more detailed information on the stratigraphy of the Athabasca Group

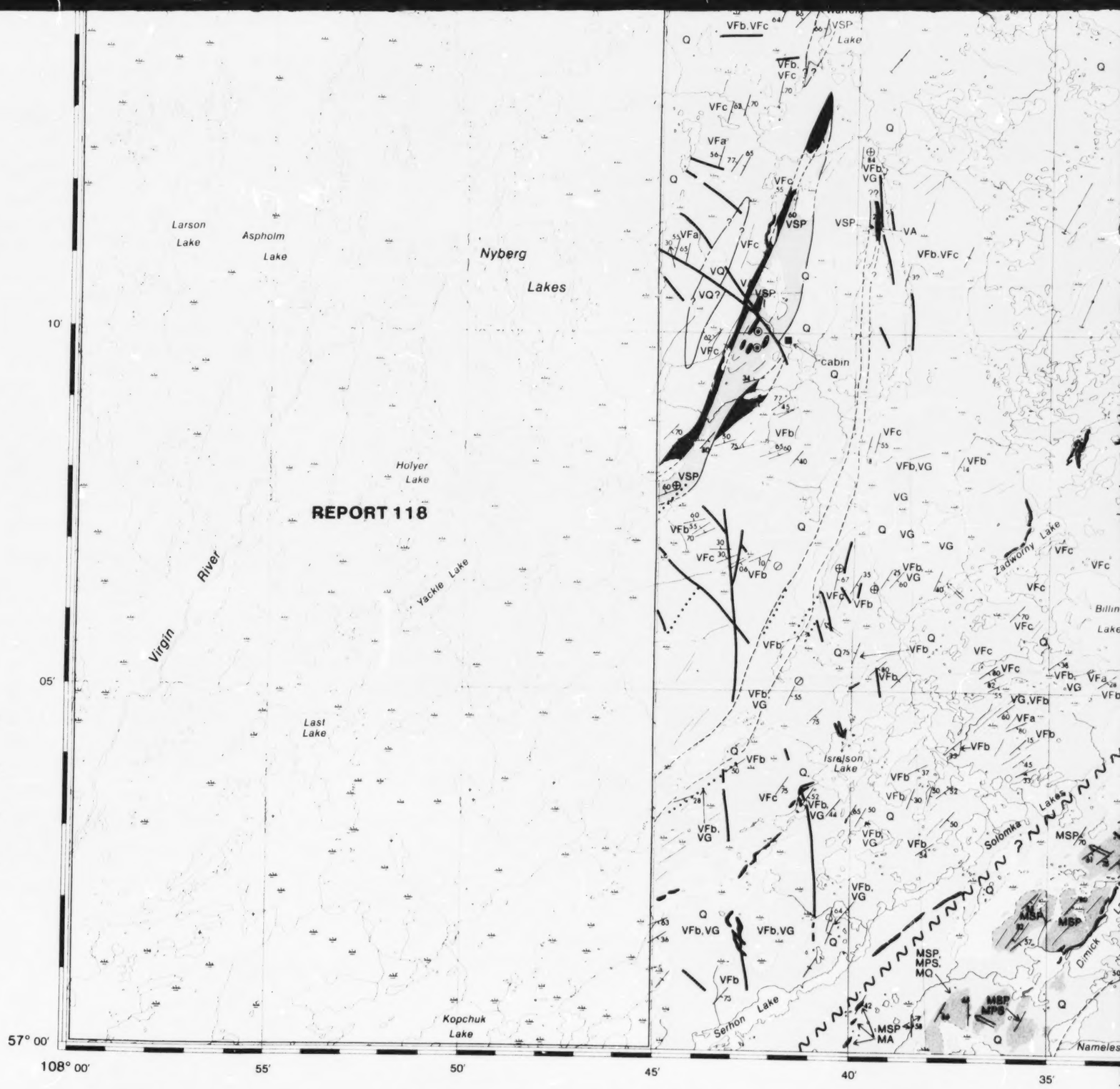
Geological interpretation in areas covered by Quaternary glacial deposits is largely based upon geophysical data obtained from mineral exploration companies.

LOCATION MAP

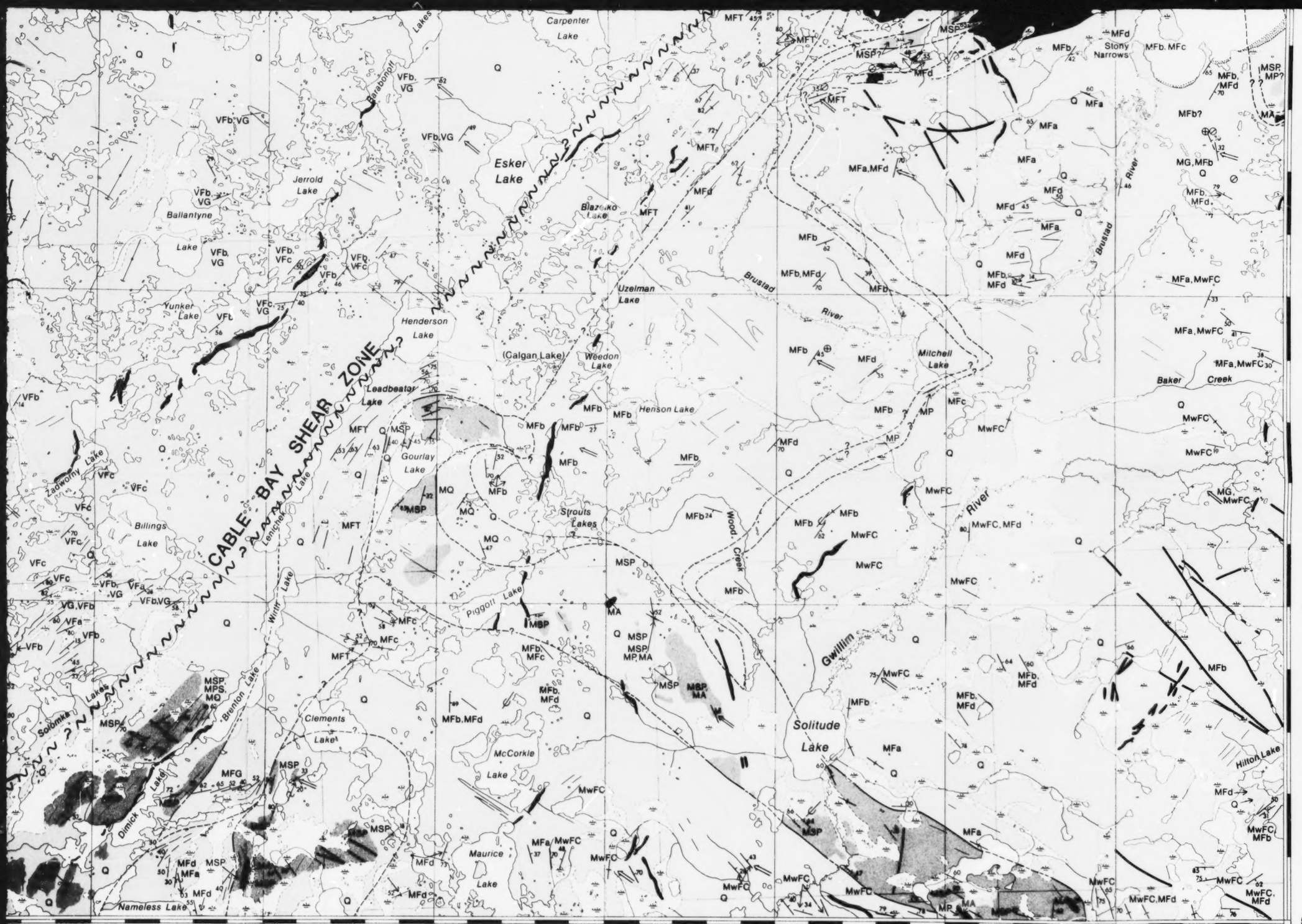


INDEX TO ADJOINING MAPS

WOLVERNAN LAKES 74-F-9	LISGAR LAKES 74-G-12	ISOLATION LAKE 74-G-11	WEITZEL LAKE 74-G-10
MONTGRAND LAKE 74-F-8			ISPATINOW ISLAND 74-G-7
NEFF LAKE 74-F-1			AMERICAN LAKE 74-G-2
M. ARTER LAKE 74-C-16	BLACK BIRCH LAKE 74-B-13	GWILLIM LAKE 74-B-14	DESNOMIE LAKES 74-B-15



REPORT 118



BASEMENT
THE CREE

Map 203A

The geological survey
with funds provided u
and Development Agr
veys.

Pre-Athabasca Group
1977 by Christopher F
D. Jones, Saskatchewa

Athabasca Group rock
mapped in 1977 by Pa
Wayne H. Pollard.

Cartography by R. O. P

Published in 1984 to a
203.

The base map was pr
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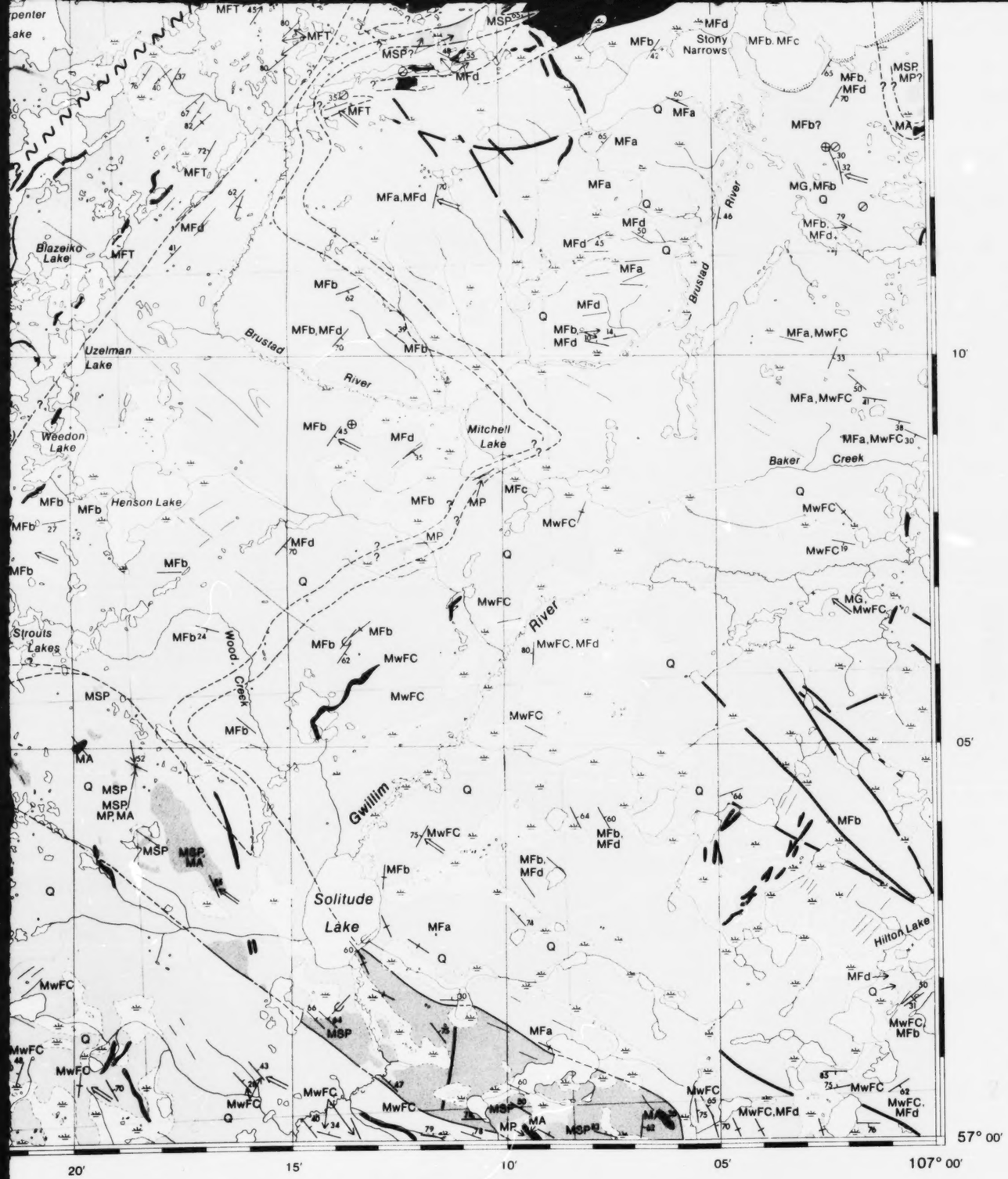

TO GIVE A REFERENCE TO NEAREST 1000 METRES

EXAMPLE	Weather Station
SQUARE Read letters of 100 000 m square	CP
EASTING Read number on grid line immediately to left of point	7
Estimate tenths of a square from this line eastward to point	.2
	72
NORTHING Read number on grid line immediately below point	5
Estimate tenths of a square from this line northward to point	.8
	58
MILITARY GRID REFERENCE (to nearest 1 000 metres)	CP 7258
If reporting beyond 18° in any direction prefix Grid Zone Designation as	13V CP7258

TEN THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 13

The geological survey leading to the production of this map was carried out with funds provided under the Canada-Saskatchewan Mineral Exploration and Development Agreement 1974-78, Reconnaissance Geoscience Surveys.

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Cartography by R. O. Pearce.

Published in 1984 to accompany Saskatchewan Energy and Mines Report 203.

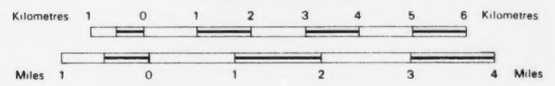
The base map was prepared from 1:50 000 scale topographic maps published by the Department of Energy, Mines and Resources, Ottawa. Approximate magnetic declination in centre of map area in 1977 was 21°11'.

BASEMENT GEOLOGY, PART OF THE CREE LAKE (SOUTH) AREA

SASKATCHEWAN

Map 203A (Sheet 1) to accompany Report 203

Scale 1:100 000



Saskatchewan Energy and Mines

Saskatchewan Geological Survey

LEGEND

QUATERNARY

Q — **Boulder tills, moraines and glaciofluvial sands and gravels**

UNCONFORMITY

PRECAMBRIAN

PROBABLE GRENVILLIAN INTRUSIVES

Diabase, dark green, medium to coarse grained, massive, subophitic

HELIKIAN SEDIMENTS

AG — **Athabasca Group**[1], mostly white or pale pink, well-bedded, flat-lying sandstones of variable grain size

UNCONFORMITY

MUDJATIK DOMAIN:

PROBABLE LATE HUDSONIAN INTRUSIVE

Leucogranite (containing less than 5 percent biotite), moderate to pale pink, medium to coarse grained, massive to poorly foliated

PROBABLE EARLY AND MIDDLE HUDSONIAN INTRUSIVES

Metamonzogranite (containing 5 to 10 percent biotite ± ferrohastingsite and abundant microcline megacrysts up to 4 cm long), pale pink, coarse grained, well foliated

MFT, MFG — **Metatrondhjemite, metatonalite and metagranodiorite** (containing 5 to 20 percent biotite ± hornblende), white to pink, medium to coarse grained, well foliated to (rarely) massive, typically homogeneous on regional scale but containing possible xenolithic patches on detailed scale

POSSIBLE APHEBIAN SUPRACRUSTALS

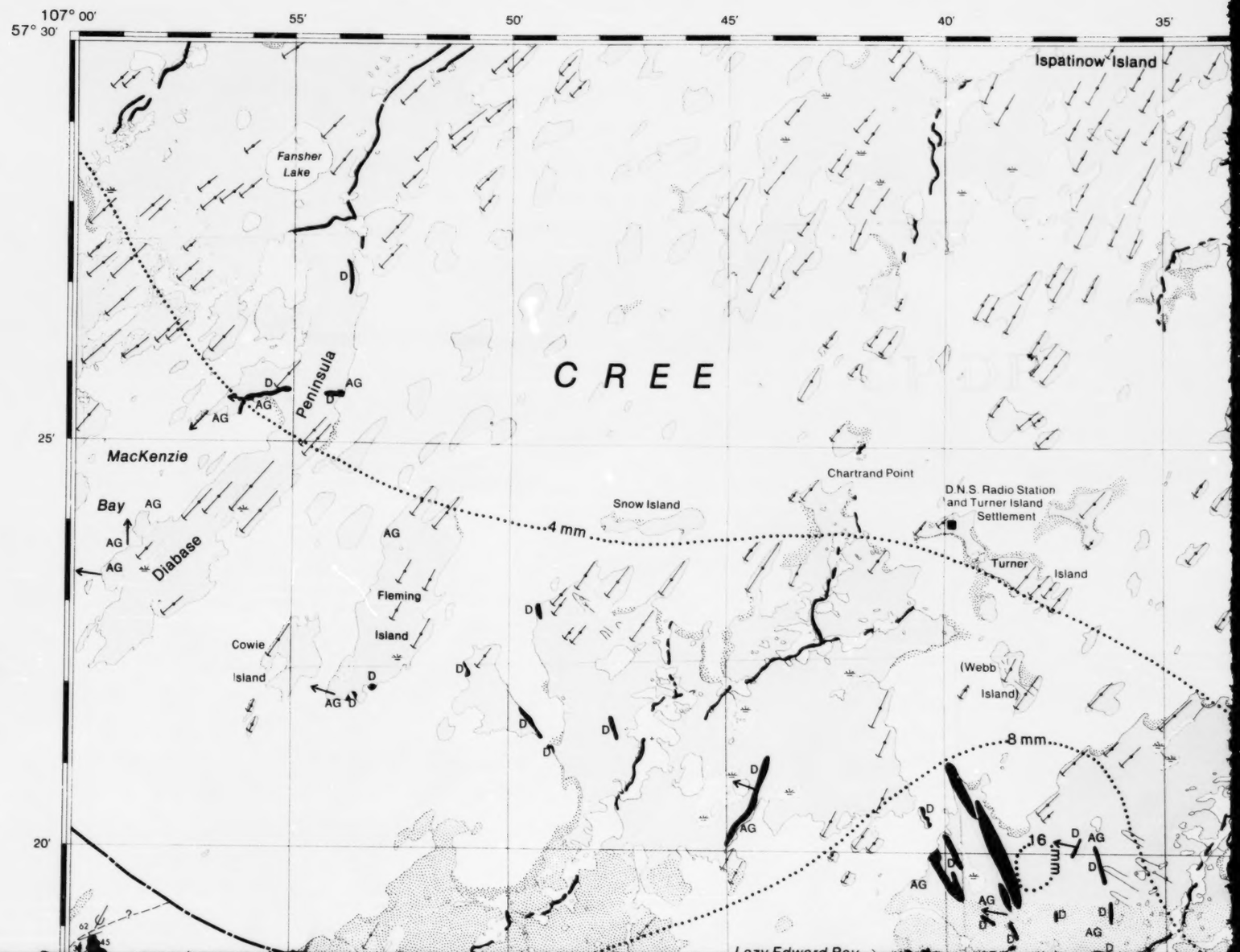
Banded iron formation, magnetite rich, waxy

Pelitic, semipelitic and psammitic gneisses, ± biotite ± cordierite ± garnet ± sillimanite ± graphite

Amphibole gneisses, containing 30 to 70 percent hornblende ± greenish hypersthene ± diopside

MwFE — **Enderbitic felsic gneisses** (typically containing 5 to 10 percent biotite ± hornblende + hypersthene ± diopside), waxy greenish brown, fine to coarse grained, poorly to well foliated

Charnockitic felsic gneisses (typically contain…



35′ 30′ 25′ 20′ 15′ 10′ 05′ 106° 00′

57° 30′

Ispatinow Island

Auriat Island

Keeping Island

Prowse Island

Ring Island

Emmerson Island

4 mm

L A K E

Grey Island

Morris Bay

MacIntyre

8 mm

16 mm

AG

Lake

25′

U.S. Radio Station
d Turner Island
Settlement

Turner Island

Channel

Stewart

Binkley Bay

Darby Bay

Webb Island)

8 mm

16 mm

D

AG

4 mm

Einarson Lake

Perpete Lake

Bourne Bay

Tommy Davis Bay

Huntley Lake

Holgar Lake

20′

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Athabasca
16 mm), re

Recession

Esker

Drumlinoid

Wind fluting

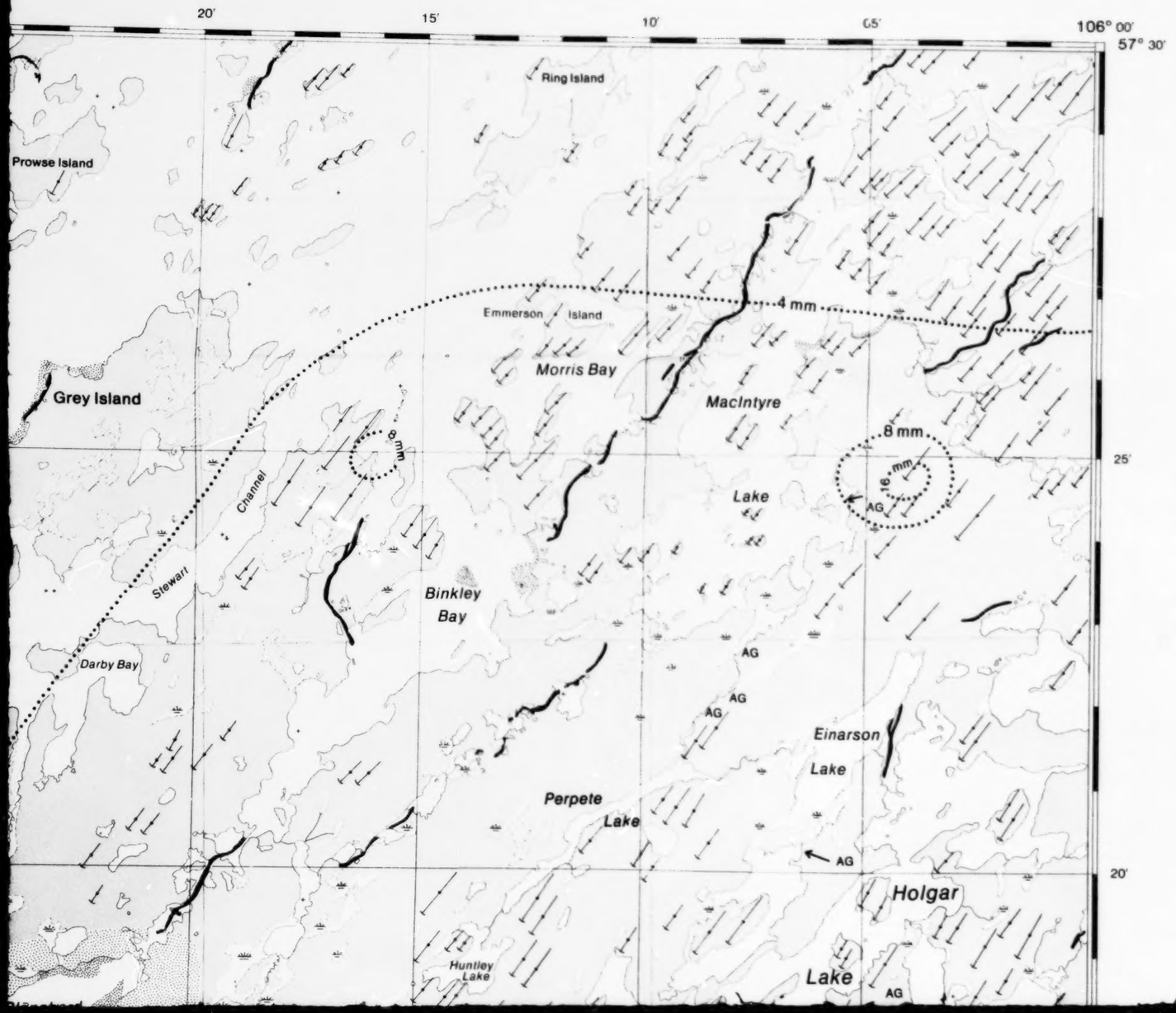
Sand dunes

Muskeg

MAP 203A (SHEET 2)

BASEMENT GEOLOGY, PART OF
THE CREE LAKE (SOUTH) AREA

NTS AREA 74G-S.E.



SYMBOLS

Geological boundary (defined, approximate or inferred; concealed)

Boundary between Mudjatik and Wollaston Domains (transitional and approximate)

Edge of Athabasca Group (approximate)

Grain-size contours in Athabasca Group ..... 8 mm

Fault or major airphoto lineament interpreted generally as master fracture

Minor airphoto lineaments interpreted generally as early gneissosity

Gneissosity and schistosity, first tectonothermal event (vertical, inclined, dip unknown, horizontal)

Plunge of lineation or minor fold hinge, second tectonothermal event (inclined, S-fold, M-fold, Z-fold)

Paleocurrent direction in Athabasca Group

Glacial striae

Erratic boulders useful in geological interpretation (diabase, Athabasca Group conglomerate (maximum clast size greater than 16 mm), regolith, pelite or semipelite, graphite pelite, calc-silicate)

Recessional moraine (approximate)

Esker

Drumlinoid ridge

Wind fluting

Sand dunes

Muskeg

Banded iron formation, magnetite rich, waxy

POSSIBLE APHEBIAN SUPRACRUSTALS

Pelitic, semipelitic and psammitic gneisses, ± biotite ± cordierite ± garnet ± sillimanite ± graphite

Amphibole gneisses, containing 30 to 70 percent hornblende ± greenish hypersthene ± diopside

MAINLY POSSIBLE ARCHEAN BASEMENT

MwFE

Enderbitic felsic gneisses (typically containing 5 to 10 percent biotite ± hornblende + hypersthene ± diopside), waxy greenish brown, fine to coarse grained, poorly to well foliated

MwFC

Charnockitic felsic gneisses (typically containing 5 to 10 percent biotite ± hornblende + hypersthene (commonly intensely altered) and small microcline megacrysts), homogeneous, waxy reddish brown, medium to coarse grained, well foliated

MF

Felsic gneisses:

MFa, mainly syenogranitic to monzogranitic (containing about 5 percent biotite ± amphibole, as well as scattered microcline megacrysts 1 to 3 cm long), typically homogeneous, dark to moderate pink, medium to coarse grained, well foliated;

MFb, mainly monzogranitic to granodioritic (containing 5 to 10 percent biotite), pale pink, medium to coarse grained, poor to moderate foliation;

MFc, mainly monzogranitic to granodioritic (containing 5 to 10 percent biotite), pale pink, medium to coarse grained, well foliated;

MFd, mainly tonalitic (containing 5 to 10 percent biotite ± amphibole), pale pink or grey, medium grained, characteristically enclosing amphibole-rich blocks up to 5 m across, inhomogeneous

WOLLASTON DOMAIN:

PROBABLE HUDSONIAN INTRUSIVE

Granite, pale pink, medium grained, massive to schistose

WOLLASTON GROUP METASEDIMENTS (Aphebian)

Calc-silicate rocks (containing biotite + scapolite ± hornblende ± diopside ± felsic minerals), white to dark green, medium to coarse grained, weakly foliated to massive; commonly assume gabbroid appearance

Quartzofeldspathic gneisses (containing about 10 percent biotite), fine to medium grained

Pelitic and semipelitic biotite gneisses (± cordierite), medium grained

WPSa

Calcareous quartzofeldspathic gneisses (containing about 10 percent biotite ± actinolite/tremolite), pink or grey, fine to medium grained

Pelitic and semipelitic biotite gneisses (± graphite ± garnet), medium to fine grained

POSSIBLE UNCONFORMITY

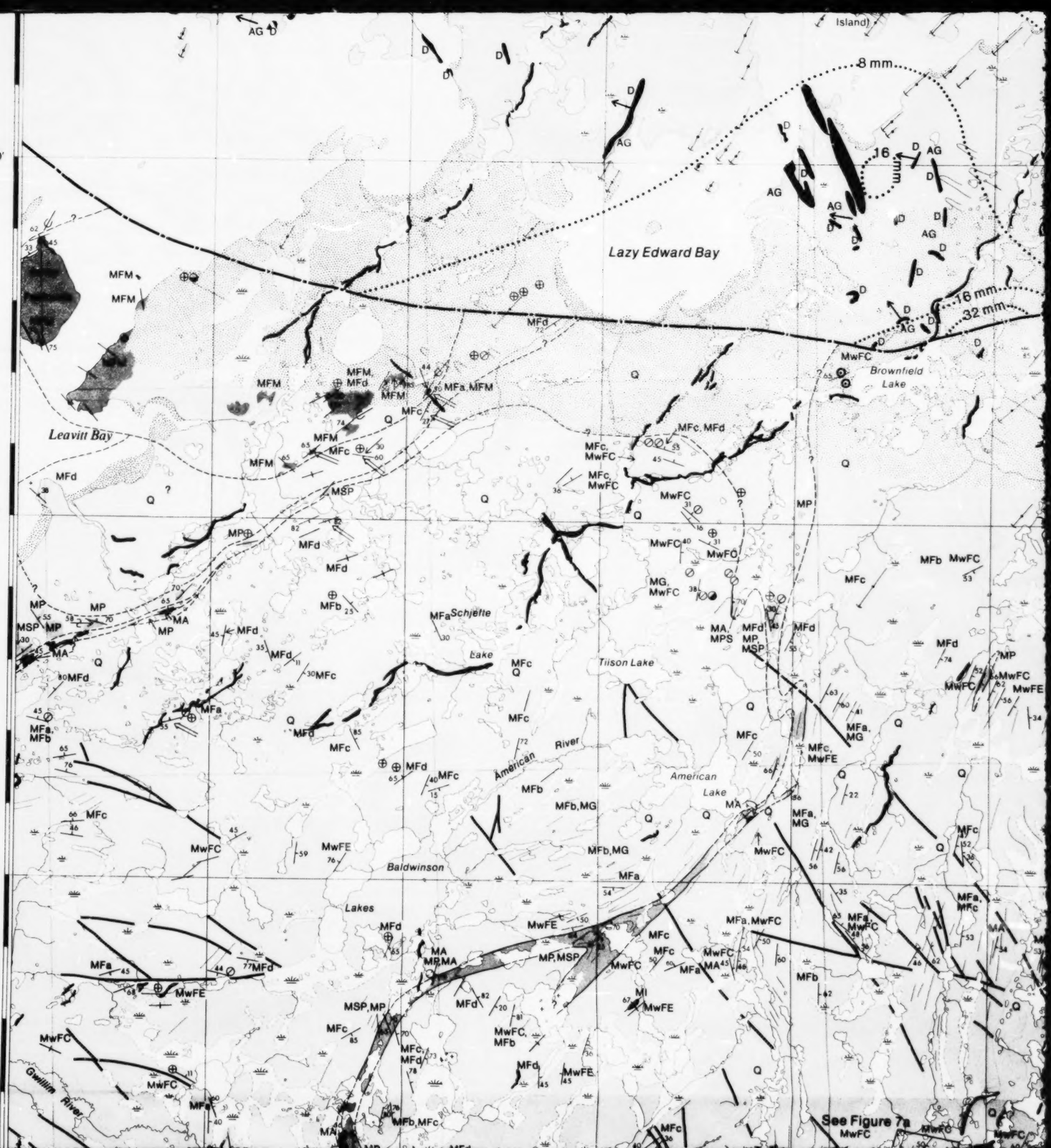
POSSIBLE ARCHEAN BASEMENT

Biotite and biotite-hornblende granite (containing about 5 percent mafics and scattered microcline megacrysts), homogeneous, dark pink to red, medium to coarse grained, well foliated

[1] See Ramaekers (1977, 1979) and Gilboy (1980) for more detailed information on the stratigraphy of the Athabasca Group

LOCATION MAP

Geological interpretation in areas covered by Quaternary glacial deposits is largely based upon geophysical data obtained from mineral exploration companies.



Tommy Davis Bay
Bourne Bay
Blanchard Lake
Perpete Lake
Emerson Lake
Holgar Lake
Morin Lake
Huntley Lake
Botham Lake
Burkosky Lake
Huston Lake
Grassick Lake
Wheeler Lake
Laverdiere Creek
Morin River
Wheeler River
Routledge River

4 mm
8 mm
16 mm
32 mm
64mm

D
AG
Q
MFa, MFc
MFb
MFb, MFd
MFc
MFa
MFd
MFb, MFa
MFa, MFc
MFa, MFd
MFa, MwFC
MFd, MA?
MFa, MG
MFa, MFc
MFb, MwFC
MFa, MwFC
MFa, MFc
MFb, MwFC
MFc, MwFC
MFc, MFd
MFb, MFd
MwFC
MwFE
MP
MSP
MA
WG
WGa
WGa?
WGaa
WPa, WSPa
WPSb ?
WPa, WSPa, WSPb ?
M1?

20'
15'
10'

Recessional moraine (a
Esker
Drumlinoid ridge
Wind fluting
Sand dunes
Muskeg
Intermittent lake
EM Conductor
Local (unofficial) name
Diamond-drill hole

The geological surv
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and Development A
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Pre-Athabasca Gro
1977 by Christophe
D. Jones, Saskatche

Athabasca Group r
mapped in 1977 by
Wayne H. Pollard.

Cartography by A.

Published in 1984
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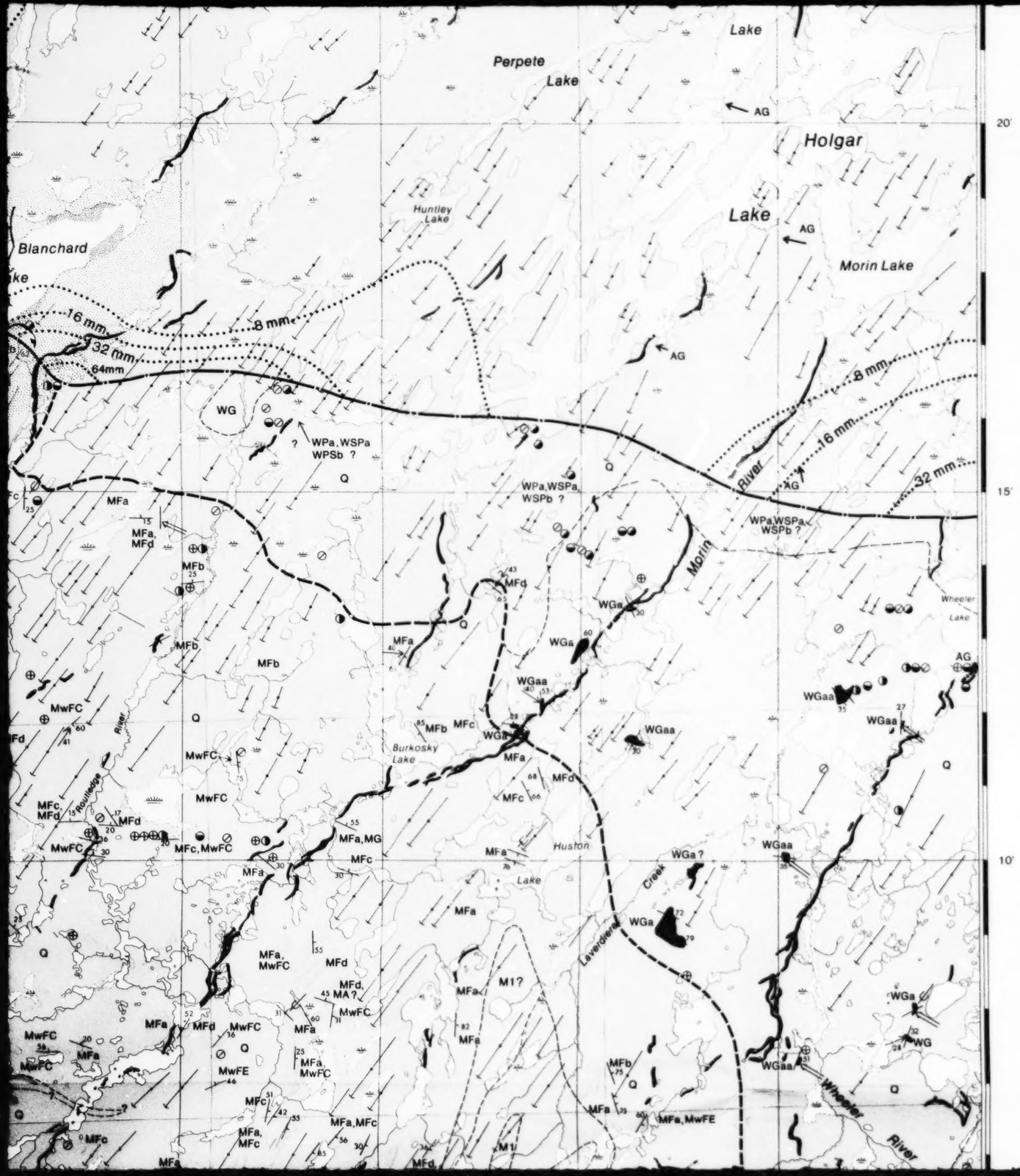

20'

15'

10'

Recessional moraine (approximate) .....

Esker .....

Drumlinoid ridge .....

Wind fluting .....

Sand dunes .....

Muskeg .....

Intermittent lake .....

EM Conductor .....

Local (unofficial) name ..... (Webb Island)

Diamond-drill hole .....

100 000 M SQUARE IDENTIFICATION

GRID ZONE DESIGNATION 13V

CP DP

TO GIVE A REFERENCE TO NEAREST 1000 METRES

EXAMPLE	Snow Island
SQUARE Read letters of 100 000 m square	CP
EASTING Read number on grid line immediately to left of point	9
Estimate tenths of a square from this line eastward to point	8
	98
NORTHING Read number on grid line immediately below point	6
Estimate tenths of a square from this line northward to point	4
	64
MILITARY GRID REFERENCE (to nearest 1 000 metres)	CP 9864
If reporting beyond 13 in any direction prefix Grid Zone Designation as	13V CP9864

TEN THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 13

The geological survey leading to the production of this map was carried out with funds provided under the Canada-Saskatchewan Mineral Exploration and Development Agreement 1974-78, Reconnaissance Geoscience Surveys.

Pre-Athabasca Group rocks and overlying drift geologically mapped in 1977 by Christopher F. Gilboy (project leader), Roberta C. Bald and Barry D. Jones, Saskatchewan Geological Survey, Precambrian Geology Sector.

Athabasca Group rocks, Helikian intrusives and overlying drift geologically mapped in 1977 by Paul Ramaekers (project leader), Alfred A. Hartling and Wayne H. Pollard.

Cartography by A. H. Buyze.

Published in 1984 to accompany Saskatchewan Energy and Mines Report 203.

The base map was prepared from 1:50 000 scale topographic manuscript

PROBABLE HUDSONIAN INTRUSIVE

WOLLASTON GROUP METASEDIMENTS (Aphebian)

POSSIBLE ARCHEAN BASEMENT

WOLLASTON DOMAIN:

Granite, pale pink, medium grained, massive to schistose

Calc-silicate rocks (containing biotite + scapolite ± hornblende ± diopside ± felsic minerals), white to dark green, medium to coarse grained, weakly foliated to massive; commonly assume gabbroid appearance

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POSSIBLE UNCONFORMITY

Biotite and biotite-hornblende granite (containing about 5 percent mafics and scattered microcline megacrysts), homogeneous, dark pink to red, medium to coarse grained, well foliated

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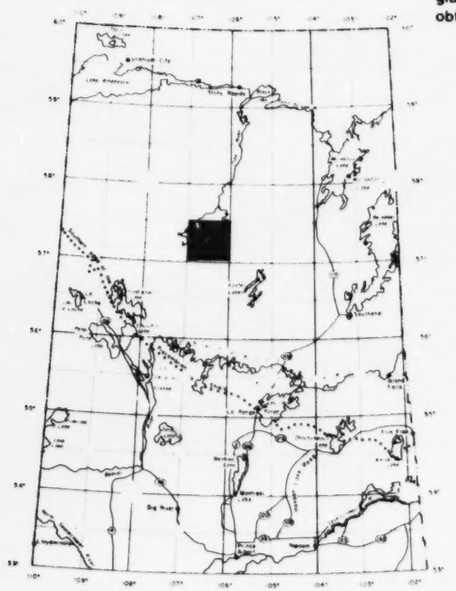
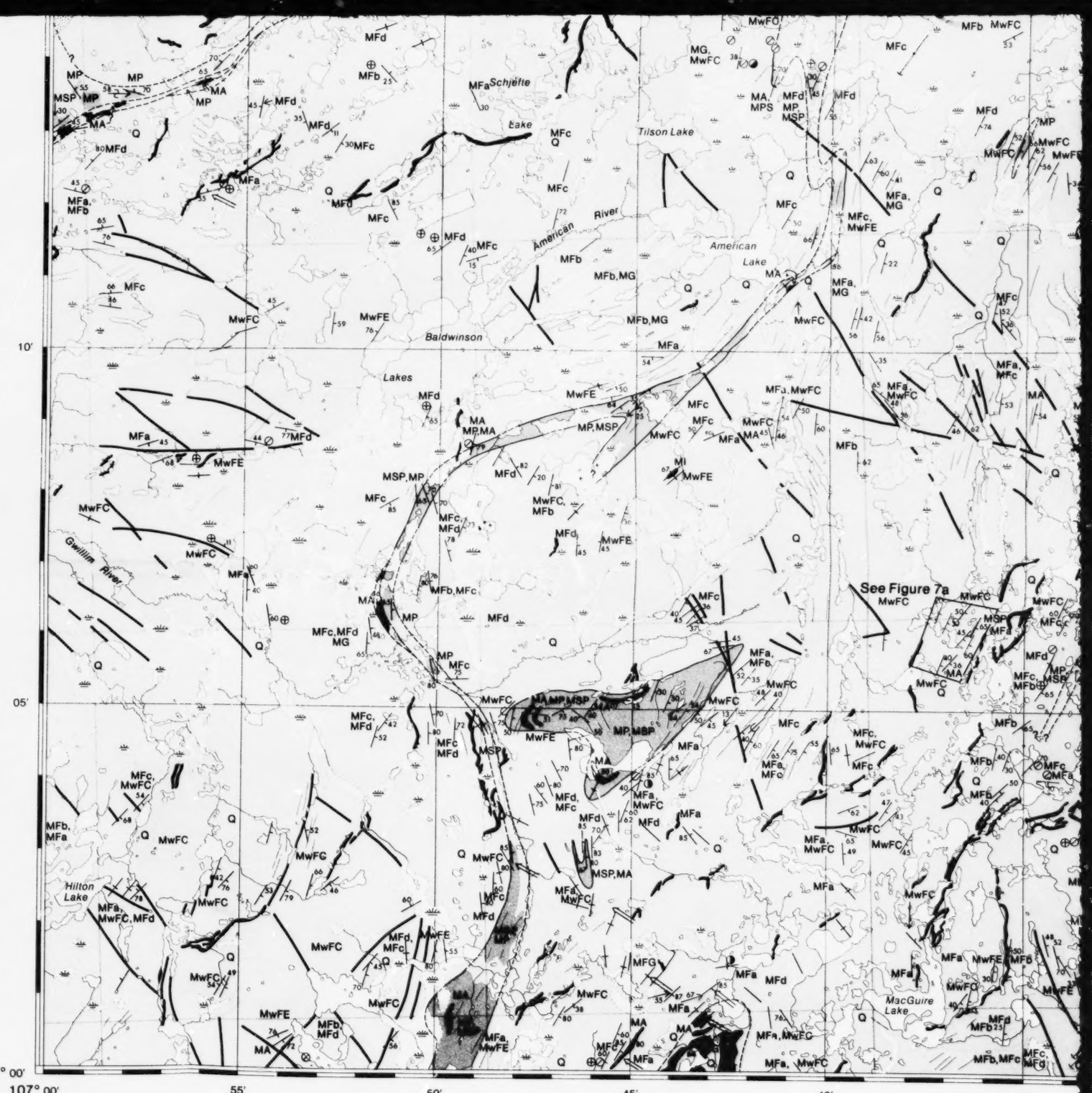
Geological interpretation in areas covered by Quaternary glacial deposits is largely based upon geophysical data obtained from mineral exploration companies.

LOCATION MAP



INDEX TO ADJOINING MAPS

ISOLATION LAKE 74-G-11	WEITZEL LAKE 74-G-10	MIDDELTON ISLAND 74-G-9	FRIESEN LAKE 74-H-12
WARNES LAKE 74-G-6			COLQUHOUN LAKE 74-H-5
ESKER LAKE 74-G-3			ZIMMER LAKE 74-H-4
GWILLIM LAKE 74-B-14	DESNOMIE LAKES 74-B-15	HAULTAIN LAKE 74-B-16	COSTIGAN LAKE 74-A-13



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Pre-Athabasca Group
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D. Jones, Saskatchewa

Athabasca Group rocks
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BASEMENT
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Map 203A (S

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TO GIVE A REFERENCE TO NEAREST 1000 METRES

EXAMPLE	Snow Island
SQUARE Read letters of 100 000 m square	CP
EASTING Read number on grid line immediately to left of point	9
Estimate tenths of a square from this line eastward to point	8
	98
NORTHING Read number on grid line immediately below point	6
Estimate tenths of a square from this line northward to point	4
MILITARY GRID REFERENCE (to nearest 1 000 metres)	CP 9864
If reporting beyond 18° in any direction prefix Grid Zone Designation as	13V CP9864

TEN THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 13

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Cartography by A. H. Buyze.

Published in 1984 to accompany Saskatchewan Energy and Mines Report 203.

The base map was prepared from 1:50 000 scale topographic maps published by the Department of Energy, Mines and Resources, Ottawa. Approximate magnetic declination in centre of map area in 1977 was 21°11'.

BASEMENT GEOLOGY, PART OF THE CREE LAKE (SOUTH) AREA

SASKATCHEWAN

Map 203A (Sheet 2) to accompany Report 203

Scale 1:100 000

Kilometres 1 0 1 2 3 4 5 6 Kilometres

Miles 1 0 1 2 3 4 Miles